JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

MAY, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

No. 1.—RESERVOIR CONSTRUCTION.

THE principle of collecting water for public or personal use, is directly connected with the introduction of water works; and preliminary to examination of the several theories or systems of construction and use which have been followed, a brief historical summary of ancient and modern practice is important, which is taken from Cresy's Encyclopædia and other works for the former, and principally from local reports for the latter.

Egypt.—In two of the prominent cities, Carthage and Alexandria, the former containing upwards of 700,000 inhabitants and the latter over 300,000, the first received its supply of water through a large aqueduct, which emptied itself into a great number of reservoirs or cisterns in different parts of the city, about 100 feet long by 30 feet wide, through earthen pipes laid for the purpose, said to be still visible; while the second was supplied from the river Nile, covered stone conduits lined with cement being carried to each private dwelling, discharging into small cisterns built for the purpose, of the same material and lining, also covered. In the wars between Rome and Alexandria, when the Roman army had obtained possession of a portion of the city, they were much surprised and annoyed by the Alexandrian general, who cut off their supply of fresh water, turning into their conduits salt water in its stead; but by their united exertions in a single night, they dug wells sufficient to supply their wants. The fact,

taken in connexion with the enormous cost of this system of distribution, goes to show very clearly their care to provide the wholesome water of a river, in preference to the unwholesome water of wells, where used by a large population. While, in the case of Carthage, these numerous reservoirs would seem to have been used for direct private supply, without introduction to each house, as is now the case in some European cities.

Recent visits to the remains of Utica, by H. B. M. ship *Harpy*, describe the main subterranean reservoir of about 320 feet diameter, with six cisterns 86 feet from it, 135 feet long, 19 feet 7 inches wide, not less than 17 feet deep, built with arched roofs, connected with each other, and in good preservation.

Greece.—On the island of Samos, a canal was cut through a mountain to obtain the supply of water from a copious and celebrated spring; and at a point near the aqueduct, several caverns were cut to receive its supply, whence the water was probably drawn by hand for use.

On the island of Tenedos there still remains an ancient stone building, in which the water used by the inhabitants was collected, after it was brought from distant springs in earthen pipes.

Among other remains of the city of Cnidus are several slabs of marble, channeled out for water conduits.

On the island of Cos, an aqueduct three miles in length is built, which supplies the inhabitants, the cover being removed to enable them to get at its contents.

In the city of Syracuse, one of the reservoirs is described as being cut out of the solid rock, as was the aqueduct which supplied it, being 57 feet long, 23 feet wide, and 10 feet deep.

In other Grecian cities conduits of stone masonry are found leading to subterranean reservoirs, arranged in a similar system of distribution.

Italy.—In the arrangements for distribution made by the engineers of Rome, the water brought to the city by the several aqueducts was received at the walls of the city in reservoirs specially adapted to each supply. The levels of the several sources at these reservoirs differed materially, that of the Anio Novus being 158·8 feet above the level of the Tiber; while of the six other aqueducts, three were above a level of 125 feet, and the other three standing at 82·5, 34·2, and 27·4 feet above this river, which at the city was 91·5 feet above the Mediterranean.

Each reservoir, or *castellum*, had "a triple cistern attached to it to receive the water. Three conduits, of equal dimensions, were connected in such a manner that when the water was more than necessary for the supply of the outer, it was discharged into that of the middle, which served all the pipes of the public fountains; one of the mains supplied the baths, the other the private houses. The object of this contrivance was to provide first for the public wants, then the baths, and afterwards private individuals.

"At the end of each of these three conduits was a receptacle

whence the general distribution was made; at the sides were two others, to take off any superabundant quantity. By such an arrangement the various supplies were regulated with the greatest nicety. The total width of the *castellum* (of the Aqua Julia) is 115 feet. No expense was spared in the construction of these stupendous edifices, which, attached to the numerous aqueducts of Rome, must have resembled palaces. Built of squared stone, and lined with brick coated with a fine cement, every precaution was taken to prevent leakage or infiltration. The several conduits and pipes were provided with valves and cocks, for shutting off or turning on a supply to any direction."—*Cresy's Encyclopædia*, p. 172.

Ample provision was also made for cleansing the several chambers by flushing ports, built in the centre, and secured by a plug or a cut stone.

Every house in Rome was supplied with water, a portion of the expenses being met by private tax on each house. In many cases fountains were placed in the courts, and in others cisterns were used, either open or covered. These were supplied from the *castellum*, principally by earthen pipes, although lead pipes were much in use in Italy. Wooden pipes were sometimes used for economy; pipes of terra cotta were also used, and iron pipes were not unknown. In some of the baths copper pipes were used, but seem to have been limited in number.

The Romans seem to have preferred the earthen pipes for distribution, as they did earthen vessels for drinking, on account of their superior coolness and purity. The tubes were made not less than two inches thick, the end of one fitting into that of the other. The joints were coated with a mixture of quicklime and oil, the pipes resting on stone blocks, to keep them in line, and in some cases they were entirely coated with cement.

In the city of Venice, all the springs met with in constructing the foundations of the houses were led into wells built to receive them. In the absence of a spring, the wells were supplied by rain water from the roof, and these supplies failing, as they sometimes do, recourse is had to the main shore for supplies brought in boats. These subterranean reservoirs are very carefully built, lined with a peculiar clay of the locality, and preserve the water in coolness and purity.

In other cities of Italy the population is supplied by public reservoirs, placed at different points throughout the city, at a level below the ground.

Turkey.—In the city of Constantinople, one of the covered reservoirs, or *cisternæ*, connected with the distribution system, still remains. It is constructed of brick covered with cement. It has a vaulted roof supported by marble columns, the cistern being 336 feet long, about 200 feet broad, and containing when filled to about 40 feet depth 25,000,000 gallons of water.

Remains of these *cisternæ* are found in Rome, independent of the *castellæ*, which received the aqueduct supply. They are also to be found in Spain.

Judea.—The city of Jerusalem is still supplied in part from the pools of Solomon, which were cisterns or reservoirs of masonry, receiving an aqueduct discharge, and works of this kind characterize that country.

The countries of Assyria and Persia, Babylon and other great cities, contained extensive provisions for water supply.

Peru.—In this country reservoirs were constructed by the Incas on the Andes, from which aqueducts were built hundreds of miles in length, exceeding in character those of Rome. One, in the valley of Condesuyu is four hundred miles long, and is still in partial use.

Mexico is also famous for the aqueduct of Chapultepec, and the line over Lake Tezcuso.

It would appear from these statements, that with the ancients the system of distribution to each private house was not universally in use, the inhabitants being obliged to go to the *cisternæ* for their more immediate supply. And, as in those cases on record, of house distribution, the open fountains, open *limariæ*, or covered *piscinæ*, were at or below the level of the ground, and fully connected by waste pipes with the system of sewerage, it is evident that the system of distribution *under pressure* was not in general use, so far as an available head within the house was concerned.

Modern Europe.—In a large number of European cities, as has been also the custom in Canadian cities, and as was the practice for many years in New York, the population is supplied from the public fountains or other sources by water carriers. The supply of the *Canal de l'Ourcq* in Paris was distributed in this way.

In other cities, as in London and Hamburg, the supply is carried to the consumers by distributing pipes, under the pressure of standpipes connected with pumping engines, reservoirs being used rather as reserves for fire purposes than for house service.

London, previous to the year 1582, derived its supply by individual resort to the Thames, to wells, and to suburban streams. About that time a tide-wheel was erected at London Bridge, which forced the water of the Thames into a cistern on a wooden building 120 feet high, from which leaden pipes carried its supply to several districts of the city, pipes of wood and stone being in occasional use at a later date. With this distribution service, under additional pumping power, which was mainly of wood up to 1810 and 1815, as also in other cities of England, the greatest head in the houses was limited to 6 feet above ground.

The character of the supply furnished the citizens of London by the nine water companies in operation previous to 1852, has this remarkable peculiarity, that it was carried on under what is called the *intermittent system*, or in other words, that each company subdivided its distribution district into convenient sections, but one of which was supplied at a time, and in no case more than once a day, sometimes not more than three times a week; and that the supply of water under the standpipe head at the engine house, was kept on each section for a daily interval varying from three-quarters of an hour to three hours,

but very rarely as long as three hours. Notwithstanding the use of cast iron distribution pipes, the elevation of this intermittent supply to the upper stories of dwellings was confined to the more expensive houses, and as a general rule, all the supplies were received in cisterns or other receptacles very near or quite below the street grade. In most cases the mains were supplied direct from the engines through the engine house standpipes, a process for which these standpipes were specially adapted.

To receive and retain for use this alternate supply, all the better class of houses were provided with cisterns, or water butts of sufficient capacity for this purpose. No such provision, however, seems to have been made for the poorer classes, who were obliged to draw their supply from short standpipes placed in the several courts, one pipe of this kind serving for from 50 to 100 houses, the water being kept in the pails, jars, buckets, &c., in which it was caught.

From the Parliamentary Reports on this subject of 1850, it appears that of 288,037 houses in the city district of supply, 17,456 houses, or about 6 per cent., were unsupplied by any direct means; in special districts the ratio sometimes being as high as 18 per cent.

In the several Reports of 1850, '51, and '52, on the disadvantages of the present London supply, the objections to this peculiarity, which also prevails in many other cities of Great Britain, are clearly and strongly urged.

The New River Company has six subsiding reservoirs within the city limits, and uses six engine stations. Two are lined with brickwork, the others being excavated in clay bottom, with side slopes of 2·5 to 1, faced with broken stone for protection from wash. Two, being 86 feet above Trinity datum, supply by gravitation. The highest service is 430 feet. Their joint area is 50 acres; level, 82, 86, 112, 154, and 400 feet; contents, about 8·5 days supply, as an average, the highest holding 1 day's supply; joint contents, 120,268,176 gallons. Daily distribution in 1849, 14,149,315 gallons.

The East London Company has five subsiding reservoirs, at datum level, 30½ acres area jointly. Contents, 32,500,000 gallons. Lined in part with Kentish ragstone, brickwork, and gravel. The sixth, lined with brickwork, on Stamford Hill, is 86 feet above, and contains 2,500,000 gallons. Daily distribution in 1850, 8,829,462 gallons; highest service, 120 feet.

The Southwark and Vauxhall Company has no reservoirs, except for subsidence and filtration from the Thames. Highest service, 185 feet.

The West Middlesex Company has two subsiding reservoirs from the Thames of 16 acres area; a reservoir on Camden Hill, less than 1 acre in area, lined with brickwork, at 111·5 feet level, containing 3,456,000 gallons; and another on Barrow Hill, lined with brick, 1·5 acres area, contents, 4,572,000 gallons, level, 167·5 feet. Daily distribution in 1849, 3,334,054 gallons; highest service, 207·5 feet.

The Lambeth Company has a reservoir on Brixton Hill, lined with brickwork with paved bottom, level, 105 feet, area, 3 acres, contents,

12,150,000 gallons, depth, 20 feet; and another on Streatham Hill, with brick walls and clay bottom, level, 185 feet, area, 1·25 acres, contents, 3,750,000 gallons. Daily distribution in 1849, 3,077,260 gallons; highest service, 350 feet.

The Chelsea Company pumps into a subsiding reservoir at low grade, 3·5 acres area, 15 feet deep. It has a reservoir at Green Park with brick walls and paved bottom, 10 feet deep, area, 1·5 acres, contents, 3,000,000 gallons; and one at Hyde Park with brick walls on concrete, area, 0·75 acre, 7 feet deep, contents, 1,021,000 gallons. Daily distribution in 1849, 3,940,730 galls.; highest service, 157 feet.

The Grand Junction Company has one reservoir at Camden Hill, with slopes lined with concrete and brick paved bottom: area, 1·75 acres; contents, 6,000,000 gallons; level, 123 feet. Daily distribution in 1849, 3,523,013 gallons; highest service, 150 feet.

The Kent Company has three reservoirs lined with concrete or Kentish ragstone: one at Greenwich Park, level, 140 feet; one at Deptford, level, 100 feet; and one at Woolwich Common, level, 200 feet. Joint capacity, 3,865,344 galls. Daily distribution in 1849, 1,079,311 gallons; highest service, 220 feet.

The Hampstead Company has a joint reservoir surface of 35 acres. Daily distribution, 427,468 gallons; highest service, 215 feet.

The metropolitan district supplied by these nine companies is about 10·5 miles long by 8 miles wide; total average daily distribution in 1849, 44,383,332 gallons; population supplied, 2,156,417; joint elevated reservoir contents, 206,000,000 gallons. From these statements may be inferred the relation borne by the London reservoirs to the distribution service, as to elevation and capacity, and the general plan of arrangement adopted.

The new supply of the Chelsea Company at Thames Ditton, embraces a supply and summit reservoir on Putney Heath, 6 miles from the engines, and 165 feet level. It combines a double covered and a small open reservoir, the former for domestic use, the latter for park and street purposes. The former is in two divisions, 20 feet deep, each 310 by 160 feet surface; contents of both, 10,150,000 gallons. The inside slopes are one to one, faced with concrete, with which the bottom is covered 1 foot thick. The roofing is of 8-inch brick arches on piers, with concrete filling in the branches, and covered with puddling. This supply inaugurates the *constant system*, or system of constant pressure for London.

Liverpool and *Glasgow* are examples of this system as in use in the United States. The Rivington Pike Reservoir is capable of supplying the former with 13,000,000 gallons daily; and for the latter, the Ryat Linn, added to the Waulkmill Glen Reservoir, the one at 298·3 feet, and the other at 283 feet level, 50 feet deep, hold 50,000,000 cubic feet of water, at a point 5 miles from the city. A filtering apartment is in use here, passing over 3,000,000 gallons per day. In cases of this kind, where flat bank slopes 3 to 1 are used, they are generally protected by rip rap walls, or a mixture of furnace cinders and small stones with clay.

United States.—Notices of a few reservoirs in this country will serve to illustrate the subjects of discussion.

The Beacon Hill Reservoir, Boston, is the most elaborate structure of its class. It is a rectangle, built above the street grades, the walls being from 41 to 58 feet high. The outside walls are built in solid cut granite masonry, with a heavy ornamental coping, the inner walls being of the same material, 5 feet thick at the base, on a concrete bed, and 3 feet at the top; the floor is paved with concrete 3 feet deep, and covered with two courses of brickwork. The level is 121·53 feet, depth of water way 13·5 feet, contents 2,678,961 gallons. The average depth in 1861, in consequence of extraordinary city consumption, was 9 feet.

The Murray Hill Reservoir, New York, is built in two distinct divisions, with retaining walls of heavy stone masonry, arched cells being constructed around the entire structure, behind the face walls; its coping grade is about 49 feet above the street. Its division wall is of concrete faced with rubble masonry, 18 feet wide at base, 7 feet at flow line, built on a concrete bed, and carried up to coping level. Its inner slopes, 1 to 1, are laid in stone masonry 15 inches thick, to 4 feet above bottom, whence they are covered with 12 ins. of concrete, also continued over the whole floor. Its level is 112 feet; contents, 38 feet deep, 21,000,000 gallons; its inner size is 386 feet square. Its flow line is 4 feet below inner coping. Its ordinary depth is about one-third of its full depth.

Prospect Hill Reservoir, Brooklyn, is built in earth-work. The inner slopes, 1·5 to 1, are puddled 2 feet thick, covered with 3 inches of concrete, and 8 inches of brickwork to the top angle, which has a coping 3 feet wide, on masonry bed. The floor is puddled 2 feet deep, covered with 4 inch brickwork grouted. Its contents are 20,000,000 gallons, depth 20 feet, level 197 feet.

The Cleveland Reservoir is on embankment, with a base 21 feet above grade. Earth retaining banks are constructed 25 feet high, inner slopes 1·75 to 1, outer 1·5 to 1. The slopes and floor are covered with 2 feet of puddling, with a facing of brick masonry. Its depth is 20 feet, level 150 feet, contents 6,000,000 gallons.

The new Reservoir, Fairmount, completed in 1852, is of earth work, with inside slopes of 1·5 to 1, lined with puddled brick-clay, 12 to 15 inches deep, covered with a layer of concrete, on which 4-inch brick masonry is laid; at the foot of the slope the brickwork abutment is 8 inches thick; the bottom is puddled, covered with brick laid flat and grouted. Its water surface is over 4 acres, contents 20,321,392 galls., depth 16 feet, level 98·14 feet. This completes the group of five divisions for this district, which are used for subsidence and supply, and aggregate 47,218,028 gallons capacity.

The Belleville Reservoir, Jersey City, N. J., is of earth work, with puddled slopes and floor, inside slopes 1·5 to 1, covered with concrete mortar and 4-inch brickwork, which is backed with rubble masonry for 5 feet below top angle, 18 inches thick. Level 158·83, contents

14,000,000 gallons, inner size 323 by 396 feet; level of force tube discharge 160·79.

The Louisville Reservoir is built in two connected divisions, in earth work, the banks being carefully worked down; inside slopes 1·5 to 1, covered with 4-inch brick masonry, which is 8 inches thick to a point 6 feet above bottom, the floor being puddled and covered with two dry flat courses of bricks. Its level is 150 feet, depth of water 20 feet, division banks 12 feet high, and 12 feet wide at top; contents 7,000,000 gallons; height of standpipe 180 feet.

The Detroit Reservoir is built in two distinct divisions, with embankments of soluble clay, carefully made, with interior puddle walls. The inner slopes are 1·5 to 1, faced with 4-inch brickwork, commenced with the intended use of 3-inch concrete backing, which does not appear to have been completed. The upper wall was laid in a temporary manner. Its level is 77·5 feet, contents 7,592,704 gallons, depth 25·5 feet, flow line 3 feet below top angle; division wall 10 feet wide at top.

The Manhattan Reservoir, New York, is built in two distinct divisions of different areas and depths, which can be connected by a pipe 15 feet below flow line. It has earth embankments, with outer retaining walls of heavy masonry, laid dry and pointed with cement. Its interior slopes are 1·5 to 1, paved with heavy dry wall from the rock blasted from its bottom. The banks have interior puddled walls. Its depths are 20 and 25 ft., water surface 31 acres, contents 150,000,000 gallons, level 115 feet. The floor is partly on rock, and is not puddled.

The new Croton Reservoir, under the specifications of 1857, is built of earth work, in two connected divisions, the top of division wall being 3 feet below flow line. The banks, which are 15 feet wide at top, and 4 feet above flow line, have interior puddle walls; the inside slopes are 1·5 to 1, covered with an 18-inch dry wall laid on 8 inches of small stones. The head of the division bank is protected by 18 inches of rubble masonry on 8 inches of concrete, carried with 10 feet face down the slopes. The puddle walls are commenced on concrete beds, or the rock-face, the floors not being puddled. Its depth is 38 feet, water area 96 acres, contents 1,029,880,145 galls. (N. Y.), level 115 feet. In 1859, the plan of slope lining was changed for a wall of solid rubble masonry.

The Hartford Reservoir is small and irregular in form, built in earth work, of compact material. Its inner slopes vary from 1·5 and 2 to 1, on different sides, and are faced with two courses of dry stone, each 9 inches thick. Puddle walls are built in the banks. Its depth is 30 feet, greatest inner length 395 feet, and width 187 feet; contents 7,830,000 gallons, level 120·94 feet.

Ridgewood Reservoir, Brooklyn, is of earth work, in two distinct divisions. The puddling is made two feet thick on all slopes excavated, and in walls, in all embankments, being carefully connected with the floor puddling, which is 18 to 24 inches thick. The inside slopes, 1·5 to 1, were covered with a dry wall of 16 inches, and had a 6-inch backing of small stones for a depth of 8 feet below flow line. This being injured by the action of surface waves in 1859, was carefully relaid

where necessary, and pointed for a depth of several inches in cement. Its depth is 20 feet, water surface 25·61 acres, contents 153,956,402 gallons, level 170 feet.

The Brookline Reservoir, Boston, which is chiefly a natural basin, has its inner slope lined with dry stone 18 inches thick, for a belt of 14 feet in width. This width was increased on account of the action of surface waves and ice. Its depth varies from 14 feet to 24 feet; contents 89,909,730 gallons, water surface 6 feet below top bank 22·31 acres, level of this surface 120·6 feet.

All the reservoirs of this country are arranged upon the *constant service* system, although instances occur of the use of standpipes, which are made to act as reservoirs under this principle, as in the Twenty-fourth ward works at Philadelphia.

(To be Continued.)

The Economic Angles in Parallel Open-work Girders.

From the Lond. Civ. Eng. and Arch. Journal, March, 1862.

Under the term open-work girders, we include all properly braced girders, whether the bracing be of the triangular character made use of in warren and lattice bridges, or of the diagonal description common in structures of older date, and in which the frame is subdivided into quadrilateral openings, which have their diagonals supplied with ties or struts.

We purpose first to point out what influence (if any) the upper and lower members of the structure, sometimes called the booms, have upon the question, when the whole material required for these, together with that for the braces, is to be rendered a minimum.

In estimating the quantity of material necessary for the different parts, we require for our present object their proportional values only. And where no great precision is demanded, we may treat of the strength of struts like ties, as independent of their lengths within moderate limits. In this preparatory discussion, we shall not draw any distinction between the amounts of material required for struts and ties subjected to equal stresses, but represent the quantity or cost or weight of any strut or tie as proportional to its length multiplied by the stress acting through it: the most convenient units of length, and of stress or weight, being chosen.

Fig. 1.

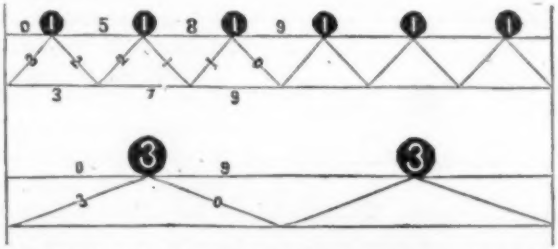


Fig. 2.

In Figs. 1 to 12, let the depth D be the same in each, and let it be taken as the unit for length; let also the span S in each = 12 times

the depth. Further, let the loading be spread uniformly over the top at the rate of $\frac{1}{2}w$ per unit of length; or $6w = W$, over the whole span of twelve units in length; w represents the unit of weight or stress = loading spread over a length of the span measuring 2 D. Let N be taken generally to represent the number of bays or parts into which the span is divided by the points at which the roadway or top-boom is supported by the bracings; when there is but one series of braces, N will be the number of triangles making up the span. Let θ represent the angle which a brace makes with the vertical, and α the angle which it makes with the horizontal direction. In Figs. 1 and 2, in which N is respectively equal to 6 and 2, let us first adopt the very usual supposition that each of the apices of the triangles receives the same share of the loading $= 6w \div N$. By the principles on which the stresses on such structures are calculated, we can readily affix to each brace, as is done in these figures, a number to denote in units the vertical component of the stress acting upon it, when all the loading is on the structure (the stresses on the booms being then the greatest). Knowing the vertical component of the stress on a brace, we obtain the horizontal stress which it induces in the booms, by multiplying the former by the tangent of θ. And since the depth of the structure is taken equal to unity, the tangent of θ is simply the horizontal stretch of the brace. Proceeding on these principles, we obtain the stresses on the booms marked against the various parts in the figures;* and to obtain the proportional quantities of the materials for the booms, we have merely to multiply these stresses by the respective lengths, thus:

$$\text{Fig. 1. } N = 6 \left\{ \begin{array}{l} \text{Top} = (5\times2+8\times2+9\times1)2 = 70 \\ \text{Bottom} = (3\times2+7\times2+9\times2)2 = 76 \end{array} \right\} = 146.$$

$$\text{Fig. 2. } N = 2 \left\{ \begin{array}{ll} \text{Top boom} = (9\times3)2 & = 54 \\ \text{Bottom do.} = (9\times6)2 & = 108 \end{array} \right\} = 162.$$

Now we have here an increase in the material required for the booms accompanying the diminution in the value of N, and this deduction is borne out by other similarly treated examples, and might very readily mislead us, as it has already misled one writer, into thinking that there is an advantage to be gained by an increase in the number of the triangles above what would be the most economical were the material of the braces alone to be reduced to a minimum; *i. e.*, that θ should be diminished or α increased above 45°, the well-known economic angle for the braces when these are arranged in isosceles triangles. This erroneous view springs from the figures 1

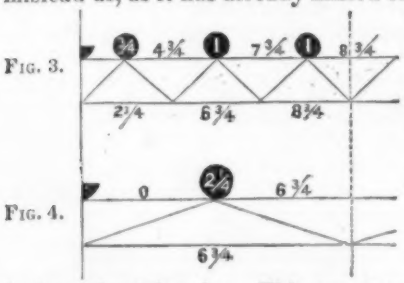


Fig. 3.

Fig. 4.

* These numbers have been omitted in some of the figures, but are all given in the detailed calculations of the booms.

and 2 not truly representing the conditions under which a uniform loading would be borne. The assumption that every one of the apices of the triangles receives an amount equal to W ÷ N is incorrect. A little consideration of the mode in which the loading is brought upon the points will convince us that the points immediately adjoining the piers receive each only three-quarters of the amount of the loading given up to each of the others, the other quarters being supported in a direct manner by the piers. The true conditions are therefore those shown by figures 3 and 4; and calculating the proportional quantities for the booms, as before, we have for

Fig. 3. N = 6 { Top = $(4\frac{3}{4}\times2+7\frac{3}{4}\times2+8\frac{3}{4}\times1)\,2 = 67{\cdot}5$; Bottom = $(2\frac{3}{4}\times2+6\frac{3}{4}\times2+8\frac{3}{4}\times2)\,2 = 73{\cdot}0$ } = 140·5

Fig. 4. N = 2 { Top boom = $(6\frac{3}{4}\times3)\,2 = 40{\cdot}5$; Bottom do. = $(6\frac{3}{4}\times6)\,2 = 81{\cdot}0$ } = 121·5

Here then we are led to an opposite deduction, and all similarly and correctly treated examples confirm it, viz: that a diminution in the material required for the booms to resist the longitudinal stresses accompanies a diminution in N; and consequently, if the consideration of the booms be admitted into the question, and the value of N be optional, the economic value of θ will be greater or that of α less than 45°.

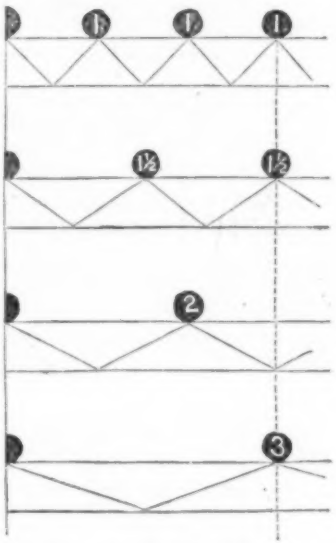


Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

When, as in the succeeding figures, the structure is suspended at the extremities of the upper member, and the loading spread uniformly over the top, then every apex will be loaded exactly to the extent of W ÷ N; so that with this arrangement of the structure, the error we have discussed above could never have been fallen into. The results for the figures 5 to 8 are as follow:

Fig. 5. N = 6 { Top = $(2\frac{1}{2}\times2+6\frac{1}{2}\times2+8\frac{1}{2}\times2)\,2 = 70$; Bottom = $(5\times2+8\times2+9\times1)\,2 = 70$ } = 140.

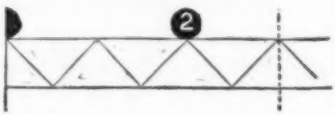
Fig. 6. N = 4 { Top = $(3\frac{3}{8}\times3+7\frac{1}{8}\times3)\,2 = 67{\cdot}5$; Bottom = $(6\frac{3}{4}\times3+9\times1\frac{1}{2})\,2 = 67{\cdot}5$ } = 135.

Fig. 7. N = 3, $\theta = 63°\,26'$ { Top = $(4\times4+8\times2)\,2 = 64$; Bottom = $(8\times4)\,2 = 64$ } = 128.

$$\text{Fig. 8. } N=2 \quad \left\{\begin{array}{ll}\text{Top} & =(4\tfrac{1}{2}\times 6)\,2 \quad =54\\ \text{Bottom} & =(9\times 3)\,2 \quad =54\end{array}\right\}=108.$$

So that we have here the same result as when the former figures 3 and 4 were correctly dealt with—a diminution of the material in the booms accompanying a diminished value of N. It would, however, be proceeding too hastily to conclude that the degree of slope of the braces directly affected the amount of material required for the booms. The fact is, we have not yet carried the analysis far enough; in the conversion of fig. 5 into fig. 7, two changes have been made: we have changed the value of the angle θ, but we have also changed the arrangement of the concentrated points of the loading, as well as the portion of the loading ($= W \div N$) which is in a direct manner imposed upon the piers. It remains, then, to discover what effect these changes will produce on the requisite material for the booms, when each is constrained to act independently of the other.

Fig. 9.



First, then, let us make such a change on the loading of fig. 5 as is exhibited in fig. 7, but without being complicated with a change in the angle θ; this we are enabled to do by adopting the arrangement shown in fig. 9, for the booms of which we have:

$$\text{Fig. 9. } N=6,\ \theta=45^\circ. \quad \left\{\begin{array}{ll}\text{Top} & =(2\times 2+6\times 2+8\times 2)\,2=64\\ \text{Bottom} & =(4\times 2+8\times 3)\,2 \quad =64\end{array}\right\}=128,$$

Which, when compared with the calculations for figs. 5 and 7, shows that the simple change of the arrangement of the loading is sufficient to account for all the difference in the results. But to make it still more clear that it is the change in the loading alone that causes the difference in the results, we add figs. 10, 11, and 12, in which the arrangement of the loading is retained exactly as in fig. 5, but the angle θ is very materially altered.

Fig. 10.

Fig. 11.

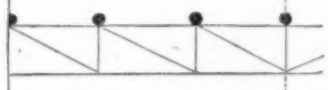
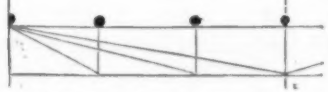


Fig. 12.



The results for these are:

$$\text{Fig. 10. } N=6,\ \theta=63^\circ 26'. \quad \left\{\begin{array}{ll}\text{Top} & =(2\times 2+6\times 2+8\times 2)\,2=64\\ \text{Bottom} & =(3\times 2+7\times 2+9\times 2)\,2=76\end{array}\right\}=140.$$

$$\text{Fig. 11. } N=6,\ \theta=63^\circ 26' \text{ \& } 0. \quad \left\{\begin{array}{ll}\text{Top} & =(5\times 2+8\times 2+9\times 2)\,2=88\\ \text{Bottom} & =(5\times 2+8\times 2)\,2 \quad =52\end{array}\right\}=140.$$

Fig. 12.
$N = 6$
$\theta = 63° 26'$,
$75° 58'$,
and $80° 32'$.

$$\left.\begin{array}{l} \text{Top} \quad = (9 \times 6)\,2 \quad\quad = 108 \\ \text{Bottom} = (2 \times 2 + 6 \times 2)\,2 = 32 \end{array}\right\} = 140.$$

All of which results agree with that for fig. 5, so that we must come to the conclusion that the value of θ has no direct influence on the quantity of material required for the booms.

The saving in the booms from a reduction in the value of N must be chiefly caused by a larger portion of the load being deposited at once upon the piers. And this reduction of the load actually imposed upon the framing of the structure, must also, *cæteris paribus*, have an influence in reducing the material required for the braces. So that the economic angle for the braces considered alone would, if we might choose any value for N, come out somewhat greater than 45°. In structures such as figs. 1—4, the loading actually thrown upon the bracing is $= W - (W \div 2N)$, and in those like figs. 5—12, it is only $= W - (W \div N)$. In lattice bridges with many series, N (= the number of bays into which S is divided by the points of concentration of the loading) is very high, and then nearly the whole of W is supported by the framing.

When there is but one series of braces under the conditions of figs. 5—8, then D the depth being taken as the unit of length, and therefore $S \div D = S$, and the unit of load or stress being taken equal to the loading lying on a length of the span $= 2D$, $W = (S \div 2)$ units of weight. For such figures, *when N is an even whole number*, we have no difficulty in arriving at the following general formulæ for the proportional quantities of material required for the booms and braces, these quantities being represented all along by the stress multiplied by the length of each part. Let the proportional quantity for the booms be represented by B, that for the bracing by R, and that for the whole girder by $G = B + R$.

N odd or even,
$$\left\{ B = \frac{W S^2}{6 D} - \frac{W S^2}{6 D N^2} = \frac{S^3}{12} - \frac{S^3}{12 N^2}. \right. \quad (1)$$

N even,
$$\left\{ \begin{array}{l} R = \frac{W}{2} N D \sec.^2 \theta, \text{ but } \sec.^2 \theta = \frac{S^2}{4 N^2} + 1, \\ \therefore = \frac{W S^2}{8 N} + \frac{W N}{2} = \frac{S^3}{16 N} + \frac{N S}{4}. \quad (2) \\ G = \frac{S^3}{12}\left(1 + \frac{3}{4} N - \frac{1}{N^2} + \frac{3 N}{S^2}\right). \quad (3) \end{array} \right.$$

Differentiating the value of G with N as the variable, we have, after clearing the co-efficient, the following equation for G a minimum,

$$\tfrac{3}{8} S^2 = \tfrac{1}{4} S^2 N - N^3. \quad (4)$$

Now to satisfy the premises, N must be an even whole number; let us therefore assign to it successively the values 4, 6, 8, 10, &c., the

resulting values of S will show the proportions of span to depth, which require *exactly* these values of N to produce the minima. The results, with the corresponding values of θ, are given in Table I.

TABLE I.

N =	4	6	8	10	12	14	16	100
S =	13·86	16·10	19·60	23·35	27·21	31·12	35·05	202·7
θ =	60° 0′	53° 18′	50° 46′	49° 25′	48° 35′	48° 1′	47° 37′	45° 23′

We may now take a particular value of S, say = 16·10 times the depth, and calculate the values of G by formula 3 to show what amount of extra material is incurred by departing from the most economical value of N (here = 6); and it will be observed from the results as given in Table II. that the variations in the values of G are surprisingly small, and would be still less so were R of its full value, as explained further on.

TABLE II.

$$S = 16{\cdot}10, \quad B = 347{\cdot}77 - \frac{347{\cdot}77}{N^2}, \text{ and } R = \frac{260{\cdot}83}{N} + 4{\cdot}025\,N.$$

N =	2 ?	4	6	8	10	12	16
B =	260·83	326·04	338·11	342·34	344·30	345·36	346·41
R =	138·46	81·31	67·62	64·80	66·33	70·04	80·70
G =	399·29	407·35	405·73	407·14	410·63	415·40	427·11
θ =	76° 3′	63° 35′	53° 18′	45° 10′	38° 50′	33° 51′	26° 35′

The case of N = 2 is exceptional; it does not satisfy, after the same manner as do the other values, the equation (4) by which Table I. is calculated, and in Table II. it produces a secondary minimum, the proper minimum being at N = 6.

It should be borne in mind that the variations in the values of B are produced solely by the variation of N, the number of points at which the loading is caused to concentrate or is supported, and that the value of θ has no direct influence on the value of B. Now if N be previously determined upon to suit the requirements of the roadway, suppose it to be = 16, then the corresponding value of B, = 346·41, is fixed, and unaltered by any value that may be assigned to θ; and, therefore, in such a case, the economic value of θ for the whole girder will be that which, under the particular conditions, gives the minimum for the bracing taken alone. When the bracing is of the isosceles character, the minimum of the bracing will accompany the nearest practicable approach to the case of $\theta = 45°$. So that for N = 16 and S = 16·10, Table II., instead of using $\theta = 26° 35'$, with R = 80·7, when one series of braces only is admitted, we may adopt a form in which there would be two series, having a prevailing angle $\theta = 45° 1'$, except at the ends, where it may be necessary to combine the two series into one, to satisfy the conditions.

In the above calculations, R as compared with B is undervalued, in the first place, because the material of the bracing as there estimated is such as would be required for a uniformly distributed *constant* loading. But when the loading is wholly or partially a movable one, the amount of material for the braces becomes increased, without, however, affecting the value of B in the least. Again, the allowance of material in proportion to stress would in practice be greater for the braces than for the booms. But this part of the question is not of that importance that we need dwell at greater length upon it here.

The conclusions that we have arrived at are:

1. When the loading and the bearings on the piers are on one level (or, in other words, when there is a full-lengthed bay adjoining each pier), and only one isosceles system of braces, as in figs. 5 to 8, and when the number of points in the span to be supported by the bracing may be of any number,—the lightest structure will be produced by a certain low value of N dependent upon the value of $S \div D$, as shown in Table I. But, on the other hand, as shown by Table II., the variation produced in the total weight of the girder by varying the value of N, is very slight, and therefore that value would be chosen which gave a sufficiently liberal number of supports to the roadway.

2. When N is fixed or previously determined upon, but the points of support on the piers, the number of series, and the arrangement of the braces, are all left optional (as in figs. 5, 10, 11, and 12), the greatest economy will be secured by causing θ to approximate to a certain economic value, to be determined for the particular kind of bracing and materials to be employed. The minimum for the bracing taken alone having in this case to be considered.

In our next, we shall discuss the economic values of θ for various forms of bracing, and draw comparisons to show their relative costs.

R. H. B.

EDINBURGH.

New Westminster Bridge.

From the Civ. Eng. and Arch. Jour., March, 1862.

It is expected by Mr. Page, the engineer, that the whole roadway of the new bridge at Westminster will be finished in May next. The last vestiges of the old structure have now been dredged out, and all the arches of the remaining half, save the fifth and sixth, are completed. The two latter will have their crowns of wrought iron girders bolted in in a few days, and as fast as each is placed, the buckle plates for the roadway will go down. Over these plates, comes a packing of blocks of pine wood and asphalte, and over all the stone pitching pavement of the road. Up to the present, the eastern half has been entirely disconnected from that which is finished. It is now being joined by a number of short cross girders or stay pieces of cast iron, and over these, as soon as the timber scaffolding is removed, the plates and roadway will be laid, so as to form one complete structure of the two halves. When the two are connected into one rigid mass, it is expect-

ed that the vibration now experienced on the western and smaller half will entirely disappear. Before the bridge can be opened, however, the half that is now finishing and closed must be entirely complete. A very broad foot pavement will be laid down, with small handsome terra-cotta tiles, cross-barred in contrary directions, to give firm foothold, and these are to be edged in with a kerb of red granite. These terra-cotta tiles are coming much into use. It is stated, as the result of experience, that they are better, drier, more easily repaired, and more durable for passenger traffic than granite itself. It has been decided to place the tramways for heavy traffic to and fro in the centre of the bridge, leaving two roadways of 20 feet wide on each side for the lighter vehicles. The side next the Houses of Parliament is completely finished, except some ornamental shields, that can be bolted into the Gothic quatrefoil spandrils of the arches at any moment. From this point, therefore, the effect of the whole structure can well be judged. The conventional street lamp-post will not intrude upon this thoroughfare, as handsome lamps and posts of cast iron have been designed, in keeping with the main architectural features of the rest of the work, and all the iron portions of it are to be painted of a pale neutral tint, excepting only the ornamental shields before spoken of, which will be emblazoned with the arms of England and Westminster, in gold and enduring colors. Since the western half has been opened for traffic, not the slightest sinking of the piers has taken place. When the entire bridge is finished, there will be two footways of 15 feet wide each, two tramways in the centre of 7 feet 6 inches wide, and two roadways for the light traffic of 20 feet each. The extreme width of London Bridge is only 56 feet from parapet to parapet, or exactly the space of the roadway of the new bridge exclusive of footpaths. When all is complete, the bed of the river is to be dredged out of rubbish, &c., some 10 or 12 feet below its present level beneath the new arches. In a month or two more, for the first time within the last twenty years, the tide will flow unimpeded up and down the Thames.

Preservation of Stone.

From the Lond. Mechanics' Magazine, February, 1862.

At a recent meeting of the Architectural Association, Mr. A. H. Church read a paper "On the Preservation of Stone." The author treated the subject chiefly from a chemical point of view, describing, first, the nature and causes of those injuries suffered by stone against which it is our object to guard. Under this division he spoke of the *weathering* of rocks, and of the natural agents of destruction with which building stone has to contend, and also of the more rapid injurious influences of artificial origin. He showed how far the destructive actions of water, carbonic, sulphurous, and sulphuric acids, &c., were chemical, and how far mechanical.

In the second part of the paper, the following principles were laid down as being likely, when carried into practice, of accomplishing the end in view:—

1. Any process to be thoroughly effectual in arresting or preventing the decay of building stones, must be easy of application, and moderate in cost.

2. It must render absorbent stone less porous, and at the same time counteract the influence of injurious bodies in the air.

3. It must effect the consolidation of stones in which the particles are loosely aggregated, and it must harden stones easily abraded by slight mechanical means.

4. The color, surface, and texture of the stone, must not be materially altered by the process.

5. The protective material must not be a mere film, but must penetrate to some depth; nor must it be liable to such contraction of the surface as shall cause a separation of particles from the stone.

6. The protective material must be less soluble in water, and less amenable to injurious atmospheric influences than the original materials of the stone.

7. No soluble salt, especially no effervescent or crystallizing salt, must remain in the stone as one of the products of the protective process.

The author, in treating thirdly of actual processes, arranged them in classes, and pointed out how far most of them were from fulfilling the necessary conditions of success. Imagine the absurdity of applying to stone as a preservative material a preparation like starch paste, itself undergoing in the course of a few days a most offensive decomposition. Such a plan with many others less palpably, but not less really, unsuitable, has actually been proposed.

Lastly, some of the results of an examination, chemical, physical, and microscopical, into the results of several of these processes were detailed. One of the most curious of these results was the effect produced on stones by the efflorescence of sulphate of soda or sulphate of magnesia upon their surface. The formation of such salts is actually favored by some of the so-called preservative processes; and it is remarkable to note upon the summit of each hair-like crystal a minute fragment of stone torn off and carried forward by the force of the crystallization. Another singular phenomenon was described as occurring when a strong solution of silica in water is applied to chalk or any soft limestone. The silica glutinizes on the surface; the film thus formed separates into small scales, and, as these fall off, it will be noticed that their under surfaces are covered with minute adherent particles of the stone or chalk.

The Acoustic Properties of Rooms.

From the London Builder, No. 961.

I think it must be admitted that sound, having its laws, is affected by the proportions of the room wherein it is emitted; consequently, a building of a certain height, length, breadth, form, and arrangement in its details, is required to enable an assemblage of persons to

hear clearly and distinctly in every part of the room. Now, I have no doubt but your numerous correspondents are able to point out many buildings which they consider as good examples in this respect; but for myself, I only know of *one room* (and I have been in many throughout the kingdom) which I consider as near perfection as possible, and that is the concert room of the Cheltenham Pump-room, Harrogate; and, being desirous of contributing my small mite of information for the benefit of those who may be pleased to make use of it, and also for the purpose of stimulating further inquiry and investigation on this important subject, I have procured from Mr. Whitehead, of Harrogate, the exact dimensions, &c., of this room, which was built in 1833, from the designs of Mr. Clark, of Leeds, and contains the following dimensions:—

	Ft.	Ins.
Length of room inside,	86	6
Width of room,	33	0
Height to ceiling line,	22	7
Ditto to centre,	24	2

The ceiling is a segment of a circle rising 1 foot 7 inches. There are nine sunk panels in the length of the ceiling, and seven in width: these are 9 inches deep. There are nine large windows along the north wall, three windows at the east end, the same at the west entrance, and on the south wall there are two doors and one window, a small orchestra about 10 feet high, and two noble $\frac{3}{4}$ Doric columns on each side of this orchestra, projecting 1 foot 6 inches from the wall.

T. B.

MECHANICS, PHYSICS, AND CHEMISTRY.

On the Strength of Steel containing different proportions of Carbon.

By Mr. T. Edward Vickers, of Sheffield.

From Newton's London Journal, March, 1862.

Three most important materials of British manufacture—wrought iron, steel, and cast iron—are combinations of iron with a smaller or larger amount of carbon. Wrought iron contains from about $\frac{1}{8}$ to $\frac{1}{2}$ per cent. of carbon, cast steel about $\frac{3}{8}$ to 2 per cent., and cast iron from $2\frac{1}{2}$ to 7 per cent. The great variety of opinions that have been expressed respecting the strength of steel when containing different proportions of carbon, led the writer to make a number of tests upon this point, the results of which are given in the present paper, with the conclusions derived from them.

The degree of carbonization in the several varieties of steel tested in the experiments ranged from about $\frac{1}{3}$ per cent. of carbon to $1\frac{1}{4}$ per cent.; the softest or least carbonized steel containing $\frac{1}{3}$ per cent. of carbon was called No. 2, and the hardest and most highly carbonized, containing $1\frac{1}{4}$ per cent. of carbon, No. 20; the intermediate numbers representing intermediate degrees of carbonization. The tests to which the steel was subjected consisted in ascertaining its tensile strength, by

means of bars of the steel broken by direct tension, and also its transverse strength, by means of axles made of the steel which were broken by the blows of a heavy ram.

Tensile Strength.—The tensile strength of the several varieties of steel was tested by a simple lever machine, in which the leverage is 220 inches to 11 inches, or 20 to 1, so that each cwt. added in the scale at the long end of the lever, produces a tension of 1 ton on the test bar at the other end of the lever. The test bars were 21½ inches long, with 14 inches of their length turned down to a uniform diameter of 1 inch. For facility of fixing the bars in the testing machine, and removing them when broken, the ends were made wedge-shaped, and the lower end was held in a conical socket in the holding down block, into which it was inserted through a longitudinal slot; the bar was then turned half round, and the upper end slipped into a wedge-shaped holder at top, whereby the bar was securely held during the testing. The following table gives the results of the trials, showing the breaking strain reduced to tons per square inch, together with the amount of elongation produced in the bars. The elongation was measured after each addition of load in the scale at the long end of the lever; and that given in the table is the final amount of elongation, previous to adding the last cwt. in the scale which caused the breakage.

Tensile Strength of Steel, containing different proportions of Carbon.

Description of Steel.	Proportion of Carbon (approximate).*	Breaking Strain Per square inch.	Elongation.
	Per cent.	Tons.	Inches.
No. 2	0·33	30·4	1·37
No. 4	0·43	34·0	1·37
No. 5	0·48	37·5	1·25
No. 6	0·53	42·5	1·12
No. 7	0·58	41·5†	0·81
No. 8	0·63	45·0	1·00
No. 10	0·74	45·5	0·69
No. 12	0·84	55·0	1·12
No. 15	1·00	60·0	1·00
No. 20	1·25	69·0	0·62

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

† There was a flaw in this test bar, which will account for its breaking at a lower strain than the preceding No.

The table shows, that the tensile strength of the steel is increased by the addition of carbon, until it is combined with about 1¼ per cent. of carbon, when it sustains about 69 tons per square inch. But beyond this degree of carbonization, the steel becomes gradually weaker, until it reaches the form of cast iron, which sustains a tensile strain of only about 6 or 6½ tons per square inch. When the test bar is turned down at one point only, instead of through a considerable length, the result obtained has been found to be different: for a bar of steel turned down to ¾ inch diameter at one point only, did not break till the strain reached 79½ tons per square inch; whereas a bar of the

same steel, turned down to 1 inch diameter for 14 inches of its length, broke with a tension of 60 tons per square inch.

Transverse Strength.—For testing the transverse strength of the several varieties of steel, axles were made of the steel in the various degrees of carbonization, which were subjected to the blows of a heavy ram until broken. The axles were all turned to 3·94 inches diameter at the centre, and 4·25 inches at the ends, and were supported on bearings 3 feet apart; they were reversed at intervals, when considerably bent by the blows of the ram. The ram weighed 1547 lbs. or nearly 14 cwts., and was dropped on the centre of the axle from a height commencing at 1 foot, and increasing at each successive blow, up to 36 feet fall, unless the axle was broken at a previous blow.

A table was appended, giving the detail of the experiment on an axle of No. 4 steel, containing about $\frac{4}{10}$ per cent. of carbon; showing that it stood 5 blows of the ram, falling from 36 feet height, before breaking, after 12 blows from lower heights of fall—the sum of all the deflections produced by the blows amounting to 56 inches.

Another table gave the general results of the series of experiments, made in a similar manner, with axles of the several varieties of steel; showing the total number of blows required to break each axle, the number that it sustained with 36 feet fall of the ram before breaking, and the sum of all the deflections produced. Three wrought iron axles were also tried in the same way,—one of the best fagoted axles that could be procured, and two scrap iron axles.

From these experiments, it appeared that, for bearing sudden and heavy blows, without regard to rigidity, the metal cannot contain too little carbon, provided it be pure and there be perfect cohesion of the particles. These qualities, however, cannot exist to the required degree in wrought iron or puddled steel; and are to be found only in cast steel, which must contain at least enough carbon to render it sufficiently fluid in melting. The steel melting process alone can effectually rid the metal of the impurities that were contained in the iron from which it is made.

There is nothing more deleterious to iron or steel than over-heating or too many heatings, and the writer believes that all welding affects the quality of the metal more or less injuriously. Cast steel has the great advantage of being less liable than any other metal in general use to become crystallized by vibration. It has already a natural crystal, and the result of the writer's experience is that its crystal can be changed into a weak form only by being over-heated. Cast steel and Swedish wrought iron have been placed where they were subjected equally to continual blows, concussions, and vibrations; and the cast steel was found to stand for a long period without change of crystal, where the Swedish iron broke very soon, showing great changes in its form of crystallization.

For most mechanical purposes, the best material in practice is one that combines the power of resisting a tolerably high tensile as well as transverse strain; one that will bear a tension of about 45 to 50 tons per square inch will generally be quite strong enough, and will be below

the point at which brittleness from too great rigidity begins. The following table gives a comparison of the first and third tables, and shows that such a material is found in the steel, Nos. 8 to 10, containing about $\frac{5}{8}$ to $\frac{3}{4}$ per cent. of carbon. There are, of course, purposes where a specially ductile or specially rigid material should be employed, but the latter should be used only in cases where it is not liable to be subjected to sudden concussions.

Transverse and Tensile Strength of Steel, containing different proportions of Carbon.

Description of Steel.	Proportion of Carbon (approximate).*	TRANSVERSE.	TENSILE.	
		Sum of Deflections.	Breaking Strain per square inch.	Elongation.
	Per cent.	Inches.	Tons.	Inches.
No. 2	0·33	58·81	30·4	1·37
No. 4	0·43	56·00	34·0	1·37
No. 5	0·48	53·56	37·5	1·25
No. 6	0·53	35·06	42·5	1·12
No. 7	0·58	38·81	41 5	0·81
No. 8	0·63	46·00	45·0	1·00
No. 10	0·74	40·31	45·5	0·69
No. 12	0·84	8·56	55·0	1.12
No. 15	1·00	4·31	60·0	1·00
No. 20	1·25	6·94	69·0	0·62

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

The superior strength of cast steel cannot be better illustrated than by stating that castings of steel, without hammering, rolling, or other means of mechanical compression, show a very high degree of strength and tenacity, far above that of castings of any other metal in practical use. Advantage is taken of this property to make bells of cast steel one-third lighter than bronze bells of the same diameter; and these lighter steel bells still bear double the breaking strain of the bronze ones. Another feature in the superior strength of castings in steel is, that they are not so liable as other metals to break when subjected to concussions during intense frost, as proved by the fact that the cast steel bells have been rung without the least injury in Russia and in Canada, when the thermometer ranged lower than 20° below zero Fahr.; while the heavier and thicker bronze bells could not be rung in the same temperature without cracking.

The same properties have also led to the manufacture of cast steel disk wheels with tyres in one solid body, for railway carriages and engines. One of these disk wheels was thus tested. The wheel was put upon an axle fixed firmly in bearings at each end, and a ball weighing 830 lbs., or nearly 7½ cwts., suspended by an iron rod 24 feet long, was drawn back and let fall so as to strike the wheel on the outside of the rim or tyre. The wheel was struck nine blows, increasing from one foot to fourteen feet in vertical height of fall, after which the axle was so much bent that the ball could not strike the wheel. The axle was then straightened by striking the wheel on the opposite side, and was

propped up to prevent bending again; and two more blows were struck from the height of 15 and 16 feet, without causing any damage to the wheel.

The results of all the experiments that have been described show that cast steel, which even to the present time is considered by many a brittle material, fit only for a cutting instrument, is in fact a metal having not only all the good and desirable properties of wrought iron in a higher degree, but at the same time freedom from most of the objectionable properties of the latter, and admitting of being employed for every mechanical purpose where great ductility, tenacity, and transverse strength are required.

In reference to the specific gravity of steel as affected by the proportion of carbon it contains, chemists and scientific writers have generally given the specific gravity of steel as about 7·850, and of wrought iron about 7·650,—that of water being 1·000; which leads to the inference that the addition of carbon to iron has the effect of increasing its density, and such is the general opinion at present. The contrary, however, has been found by the writer to be the fact, namely, that pure iron decreases in density the more carbon there is combined with it. The low specific gravity of wrought iron above stated, must therefore have been obtained from common English merchant iron, a piece of which gave a specific gravity of 7·644, which very nearly agrees with that abovementioned; and must be owing to the impurities contained in the iron. The specific gravity of one of the purest and softest Swedish irons is 7·894; and that of the iron from which the steel was made for all the experiments that have been described above is about 7·860. A table, appended to the paper, gives the specific gravities as ascertained by experiment of the successive gradations of steel, from No. 2, containing about $\frac{1}{3}$ per cent. of carbon, up to No. 20, containing about $1\frac{1}{4}$ per cent., the results having been all obtained with pieces of metal of considerable size, varying from $2\frac{3}{4}$ to $4\frac{1}{2}$ ozs. in weight.

The specific gravities of the steel No. 2 and 4 appeared to be greater than that of the original iron; but this may be attributed to the iron being freed from impurities in the melting. The conclusion therefore derived from the tabulated figures is, that every successive addition of carbon to pure iron renders the metal less dense or diminishes its specific gravity.

—

Mr. Vickers exhibited a number of strips of steel plate $\frac{5}{16}$ inch thick, which had been tested to show how far they could each be bent before cracking, when containing different proportions of carbon. Also a large cast steel pinion, and one of the steel axles that had been tested. After testing the axles, he had rolled down the broken pieces into plates $\frac{5}{16}$ inch thick, and tried them by bending, as shown by the other specimens exhibited. The softest steel, called No. 2 in the tables of experiments, had a tensile strength of only 30 tons per sq. inch, but the test plate made of it bore bending double without cracking, showing a great degree of toughness; while the most highly carbonized

quality, No. 20, had the greatest tensile strength, amounting to 69 tons per sq. inch, but was so brittle that it snapped asunder without bending more than about 45° out of the straight line. For the experiments on axles, in order to obtain the most correct results from wrought iron axles for comparison with those of steel, he got the best wrought iron axle he could of the regular fagoted make from a railway company, and also two scrap axles from makers who knew they were going to be tested; but the last two turned out worse than had been expected, and much inferior to the first.

One circumstance to be noticed respecting the mode of testing the tensile strength of bars was, that the results obtained with long test bars were different from those given by short ones. In a number of experiments upon this point he had found it to be regularly the case, that if the test bar were turned down to the required diameter at one point only of its length, it would stand one-third more strain than if turned down to the same diameter throughout a length of 14 inches. This was a fact of much importance, as affecting the value of many experiments.

Mr. H. Maudslay observed, that in turning down a long length of the test bar, each part of that length was subjected to the strain, and therefore the test was exposed to all the chances of weak places occurring from irregularity in make of the bar at any point of its length; but when the bar was turned down at one part only, the chance of breaking at a weak place was confined to that small length only.

Mr. Vickers thought the result could not be merely an average of chances, for he had noticed that the bar was always stronger when turned down at one point only, in the manner described. He thought it might arise from the strain producing a greater effect in stretching the bar and reducing its diameter when turned down of uniform diameter for a long length, since steel always stretched considerably before breaking. The breakage occurred, however, at various points in the length turned down—not at the centre only.

In answer to an inquiry of the Chairman, Mr. Vickers stated that steel axles were used almost universally on the German railways, and also steel tyres and wheels. A number of the steel axles of the make now shown were in use there, and some of the cast steel wheels. Very few steel axles had yet been tried in England, but many steel tyres were now used.

Mr. E. Riley asked what iron the steel was made from, and how far it was free from carbon in its original state previous to being converted into steel.

Mr. Vickers said, the iron used was Swedish iron, which he had tested previously, and believed to be as free from carbon as possible.

Mr. E. Riley doubted the freedom of the iron from carbon, and believed a small quantity of carbon was essential in wrought iron, without which it was useless. From experiments he had made he had found that the best wrought iron, after being melted, was always red-short, and would not work at all, but was useless as wrought iron; and con-

sidered this was due to its being deprived of the small per centage of carbon it contained, by the scale on its surface and the air in the melting pot. He had also found experimentally that fused wrought iron from the best ores was red-short and useless when made by reducing them with too small an amount of carbon, so as to leave oxide of iron in the cinder, which prevented any carbon from combining with the iron. This defect, however, was easily remedied by adding carburet of manganese, which supplied the requisite amount of carbon; and, moreover, the oxide of manganese acted also as a useful flux in separating some of the impurities contained in the iron: the addition of 1 per cent. of carburet of manganese to fused wrought iron made the iron work well, and prevented its being red-short.

The Chairman knew no question of so much importance to engineers as the effect of carbon on iron and steel, since the various qualities of both depended mainly on the proportion of carbon combined with them. A haze of doubt still hung over the subject, and called for further investigations to clear it away; but the period was now dawning when iron would be used in the form of mild cast steel, and an age of steel appeared likely to supersede that of iron. Tabulated experiments giving definite results, such as those in the paper, were the most efficient means of solving the question; and such information placed in the hands of engineers was of special value in enabling them to draw their own conclusions from the results obtained.

Proceedings Insti. Mech. Engineers, July 31, 1861.

Long Tube Barometer.

From the London Mechanics' Magazine, December, 1861.

After a recent meeting of the Institute of Civil Engineers, Mr. R. Howson exhibited in the library a Barometer, consisting of a long tube freely suspended open end downwards, a cistern which was of a tubular shape, and a "stalk." The stalk was a glass tube, sealed at both ends, attached firmly at its lower end to the bottom of the cistern, and rising axially up the tube until it nearly reached the surface of the mercurial column. The consequence of this arrangement was, that the top of the stalk came into the region of very low pressure, and there was an excess of pressure tending to force the cistern upwards. This excess was represented by the weight of the cistern (and stalk), and the contained mercury, so that under a given atmospheric pressure, the cistern would always hang suspended at a given level. When the pressure of the atmosphere rose, a portion of mercury left the cistern and passed into the tube, and the cistern also arose, until the level was replaced by the immersion of the glass which formed the tube. When the pressure fell, the converse took place. An elongated scale was thus produced, the extent of range being dependent upon the relative areas of the tube, and of the glass which composed it. The action might also be simply viewed as that of a long piston, or plunger, with a liquid packing, having a vacuum on its upper side, and a self-graduating weight attached to its lower side.

Reading the Barometer.

From Mitchell's Steam-shipping Journal, No. 57.

The following manual of the barometer has been compiled by Rear Admiral Fitzroy, and published by the Board of Trade:—

Familiar as the practical use of weather-glasses is, at sea as well as on land, only those who have long watched their indications and compared them carefully are really able to conclude more than that the rising glass* usually foretells less wind or rain, a falling barometer more rain or wind, or both; a high one fine weather, and a low the contrary. But useful as these general conclusions are in most cases, they are sometimes erroneous, and then remarks may be rather hastily made, tending to discourage the inexperienced.

By attention to the following observations (the results of many years practice and many persons experience), any one not accustomed to use a barometer may do so without difficulty.

The barometer shows whether the air is getting lighter or heavier, or is remaining in the same state. The quicksilver falls as the air becomes lighter, rises as it becomes heavier, and remains at rest in the glass tube while the air is unchanged in weight. Air presses upon everything within about 40 miles of the world's surface like a much lighter ocean, at the bottom of which we live, not feeling its weight, because our bodies are full of air,† but feeling its currents, the winds. Towards any place from which the air has been drawn by suction,‡ air presses with a force or weight of nearly 15 lbs. on a square inch of surface. Such a pressure holds the limpit to the rock when, by contracting itself, the fish has made a place without air§ under its shell. Another familiar instance is that of the fly, which walks on the ceiling with feet that stick. The barometer tube, emptied of air, and filled with pure mercury, is turned down into a cup or cistern containing the same fluid, which feeling the weight of air, is so pressed by it as to balance a column of about 30 inches (more or less) in the tube, where no air presses on the top of the column.

If a long pipe, closed at one end only, were emptied of air, filled with water, the open end kept in water, and the pipe held upright, the water would rise in it more than 30 feet. In this way water barometers have been made. A proof of this effect is shown by any well with a sucking pump, up which, as is commonly known, the water will rise nearly 30 feet by what is called suction, which is, in fact, the pressure of air towards an empty place.

The words on scales of barometers should not be so much regarded for weather indications as the rising or falling of the mercury, for if it stand at "changeable," and then rise towards "fair," it presages a change of wind or weather, though not so great as if the mercury had risen higher; and, on the contrary, if the mercury stand above "fair," and then fall, it presages a change, though not to so great a degree as

* Glass, barometer, column, mercury, quicksilver, or hand.
† Or atmosphere, or the atmospheric fluid which we breathe.
‡ Or exhaustion. § A vacuum.

if it had stood lower; besides which, the direction and force of wind are not in any way noticed. It is not from the point at which the mercury may stand that we are alone to form a judgment of the state of the weather, but from its rising or falling, and from the movements of immediately preceding days as well as hours, keeping in mind effects of change of direction and dryness or moisture, as well as alteration of force or strength of wind.

In this part of the world, towards the higher latitudes, the quicksilver ranges, or rises and falls, nearly three inches—namely, between about thirty inches and nine-tenths (30·9) and less than twenty-eight inches (28·0) on extraordinary occasions; but the usual range is from about thirty inches and a half (30·5) to about twenty-nine inches. Near the Line, or in equatorial places, the range is but a few tenths, except in storms, when it sometimes falls to twenty-seven inches.

The sliding scale (vernier) divides the tenths into 10 parts each, or hundredths of an inch. The number of divisions on the vernier exceeds that in an equal space of the fixed scale by one.

By a thermometer the weight of air is not shown. No air is within the tube; none can get in. But the bulb of the tube is full of mercury, which contracts by cold and swells by heat, according to which effect the thread of metal in the small tube is drawn down or pushed up so many degrees, and thus shows the temperature.*

If a thermometer have a piece of linen round the bulb, wetted enough to keep it damp by a thread or wick dipping into a cup of water, it will show less heat than a dry one, in proportion to the dryness of the air and quickness of drying.† In very damp weather, with or before rain, fog, or dew, two such barometers will be nearly alike.

For ascertaining the dryness or moisture of air, the readiest and surest method is the comparison of two thermometers, one dry, the other just moistened and kept so: Cooled by evaporation as much as the state of the air admits, the moist (or wet) bulb thermometer shows a temperature nearly equal to that of the other one when the atmosphere is extremely damp or moist; but lower at other times, in proportion to the dryness of air and consequent evaporation—as far as 12 or 15 degrees in this climate, 20 or even more elsewhere. From four to eight degrees of difference is usual in England, and about seven is considered healthy for inhabited rooms.

The thermometer fixed to a barometer intended to be used only as a weather glass shows the temperature of air about it nearly, but does not show the temperature of mercury within exactly. It does so, however, near enough for ordinary practical purposes, provided that no sun, nor fire, nor lamp heat is allowed to act on the instrument partially.

The mercury in the cistern and tube being affected by cold or heat, makes it advisable to consider this when endeavoring to foretell coming weather by the length of the column.

Briefly, the barometer shows weight or pressure of the air; the

* Thirty-two degrees is the point at which water begins to freeze or ice to thaw. † Evaporation.

thermometer, heat and cold, or temperature; and the wet thermometer, compared with a dry one, the degree of moisture or dampness.*

It should always be remembered that the state of the air foretells coming weather, rather than shows the weather that is present—an invaluable fact too often overlooked; that the longer the time between the signs and the change foretold by them, the longer such altered weather will last; and, on the contrary, the less the time between a warning and a change, the shorter will be the continuance of such foretold weather.

To know the state of the air, not only barometers and thermometers should be watched, but the appearances of the sky should be vigilantly noticed.

If the barometer has been about its ordinary height, say near 30 inches (at the sea level),† and is steady, or rising, while the thermometer falls, and dampness becomes less, north-westerly, northerly, or north-easterly wind, or less wind, less rain or snow may be expected.

On the contrary, if a fall takes place with a rising thermometer and increased dampness, wind and rain may be expected from the south-eastward, southward, or south-westward.

A fall with a low thermometer foretells snow.

Exceptions to these rules occur when a north-easterly wind, with wet (rain, hail, or snow), is impending, before which the barometer often rises (on account of the direction of the coming wind alone), and deceives persons who from that sign only (the rising) expect fair weather.

When the barometer is rather below its ordinary height—say down to near 29½ inches (at the sea level)—a rise foretells less wind, or a change in its direction towards the northward, or less wet; but when it has been very low, about 29 inches, the first rising usually precedes or indicates strong wind; at times heavy squalls from the north-westward, northward, or north-eastward—after which violence a gradually rising glass foretells improving weather if the thermometer falls; but if the warmth continue, probably the wind will back (shift against the sun's course), and more southerly or south-westerly wind will follow, especially if the barometer rise is sudden.

The most dangerous shifts of wind, or the heaviest northerly gales, happens soon after the barometer first rises from a very low point; or, if the wind veers gradually, at some time afterwards.

Indications of approaching changes of weather and the direction and force of winds are shown less by the height of the barometer than by its falling or rising. Nevertheless, a height of more than thirty (30·0) inches (at the level of the sea) is indicative of fine weather and moderate winds; except from east to north occasionally.

The barometer is said to be falling when the mercury in the tube is sinking, at which time its upper surface is sometimes concave or hollow; or when the hand moves to the left. The barometer is rising

* The two thus combined make a hygrometer, for which some kinds of hair, grass, or seaweed may be a make-shift.

† It differs, or stands lower, about a tenth of an inch for each hundred feet of height directly upwards, or vertically, above the sea; its average height being 29·94 inches at the mean sea level in England. Allowances must, therefore, be made for barometers on high land or in buildings.

when the mercurial column is lengthening; its upper surface being convex or rounded, or when the hand moves to the right.

A rapid rise of the barometer indicates unsettled weather; a slow movement the contrary; as likewise a steady barometer, which, when continued, and with dryness, foretells very fine weather.

A rapid and considerable fall is a sign of stormy weather and rain (or snow). Alternate rising and sinking indicates unsettled and threatening weather.

The greatest depressions of the barometer are with gales from S. E., S., or S. W.; the greatest elevations, with wind from N. W., N., or N. E., or with calm.

Though the barometer generally falls with a southerly and rises with a northerly wind, the contrary sometimes occurs; in which cases, the southerly wind is usually dry with fine weather, or the northerly wind is violent and accompanied by rain, snow, or hail; perhaps with lightning.

When the barometer sinks considerably, much wind, rain (perhaps with hail), or snow will follow; with or without lightning. The wind will be from the northward, if the thermometer is low (for the season) —from the southward, if the thermometer is high. Occasionally a low glass is followed or attended by lightning only, while a storm is beyond the horizon.

A sudden fall of the barometer, with a westerly wind, is sometimes followed by a violent storm from N. W., or N., or N. E.

If a gale sets in from E. or S. E., and the wind veers by the S., the barometer will continue falling until the wind is near a marked change, when a lull *may* occur; after which the gale will soon be renewed, perhaps suddenly and violently, and the veering of the wind towards the N. W., N., or N. E. will be indicated by a rising of the barometer with a fall of the thermometer.

Three causes (at least)* appear to affect a barometer:—

1. The direction of the wind—the north-east wind tending to raise it most—the south-west to lower it the most, and wind from points of the compass between them proportionally as they are nearer one or the other extreme point.

N. E. and S. W. may therefore be called the wind's extreme bearings (rather than poles).

The range or difference of height shown, due to change of direction only, from one of these bearings to the other (supposing strength or force, and moisture to remain the same), amounts in these latitudes to about half an inch (as read off).

2. The amount—taken by itself—of vapor, moisture, wet, rain, or snow in the wind, or current of air (direction and strength of wind remaining the same), seems to cause a change amounting in an extreme case to about half an inch.

3. The strength or force alone of wind, from any quarter (moisture and direction being unchanged), is preceded or foretold by a fall or

* Electrical effects are yet uncertain.

rise, according as the strength will be greater or less, ranging in an extreme case to more than two inches.

Hence, supposing three causes to act together—in extreme cases—the height would vary from near 31 inches (30·9) to about 27 inches (27·0), which has happened, though rarely (and even in tropical latitudes).

In general, the three causes act much less strongly, and are less in accord; so that ordinary varieties of weather occur much more frequently than extreme changes.

Another general rule requires attention; which is, that the wind usually appears to veer, shift, or go round with the sun (right-handed, or from left to right),* and that when it does not do so, or backs, more wind or bad weather may be expected instead of improvement.

It is not by any means intended to discourage attention to what is usually called "weather wisdom." On the contrary, every prudent person will combine observation of the elements with such indications as he may obtain from instruments; and will find that the more accurately the two sources of foreknowledge are compared and combined, the more satisfactory their results will prove.

A barometer begins to rise considerably before the conclusion of a gale, sometimes even at its commencement. Although it falls lowest before high winds, it frequently sinks very much before heavy rain. The barometer falls, but not always, on the approach of thunder and lightning.† Before and during the earlier part of settled weather it usually stands high and is stationary, the air being dry.

Instances of fine weather with a low glass occur, however, rarely, but they are always preludes to a duration of wind or rain, if not both.

After very warm and calm weather, a storm or squall, with rain, may follow; likewise at any time when the atmosphere is heated much above the usual temperature of the season.

Allowance should invariably be made for the previous state of the glasses during some days, as well as some hours, because their indications may be affected by distant causes, or by changes close at hand. Some of these changes may occur at a greater or less distance, influencing neighboring regions, but not visible to each observer whose barometer feels their effect.

There may be heavy rains or violent winds beyond the horizon, and the view of an observer, by which his instruments may be affected considerably, though no particular change of weather occurs in his immediate locality.

It may be repeated that the longer a change of wind or weather is foretold before it takes place, the longer the presaged weather will last; and, conversely, the shorter the warning the less time, whatever causes the warning, whether wind or a fall of rain or snow, will continue.

Sometimes severe weather from the southward, not lasting long,

* With watch-hands in the northern hemisphere, but the contrary in south latitude. This, however, is only apparent; the wind is actually circulating in the contrary direction.

† Thunder-clouds rising from north-eastward, against the wind, do not usually cause a fall in the barometer.

may cause no great fall, because followed by a duration of wind from the northward, and at times the barometer may fall with northerly winds and fine weather, apparently against these rules, because a continuance of southerly wind is about to follow. By such changes as these one may be misled, and calamity may be the consequence, if not duly forewarned.

A few of the more marked signs of weather, useful alike to seaman, farmer, and gardener, are the following:—

Whether clear or cloudy—a rosy sky at sunset presages fine weather; a red sky in the morning bad weather, or much wind (perhaps rain); a grey sky in the morning, fine weather; a high dawn, wind; a low dawn, fair weather.*

Soft-looking or delicate clouds foretell fine weather, with moderate or light breezes; hard edged, oily-looking clouds, wind. A dark, gloomy, blue sky is windy; but a light, bright blue sky indicates fine weather. Generally, the softer clouds look, the less wind (but perhaps more rain) may be expected; and the harder, more "greasy," rolled, tufted, or ragged, the stronger the coming wind will prove. Also, a bright yellow sky at sunset presages wind; a pale yellow, wet;—and thus, by the prevalence of red, yellow, or grey tints, the coming weather may be foretold very nearly; indeed, if aided by instruments, almost exactly.

Small inky-looking clouds foretell rain; light scud-clouds driving across heavy masses show wind and rain; but, if alone, may indicate wind only.

High upper clouds crossing the sun, moon, or stars, in a direction different from that of the lower clouds, or the wind then felt below, foretell a change of wind.†

After fine clear weather, the first signs in the sky of a coming change are usually light streaks, curls, wisps, or mottled patches of white distant clouds, which increase, and are followed by an overcasting of murky vapor that grows into cloudiness. This appearance, more or less oily, or watery, as wind or rain will prevail, is an infallible sign.

Usually the higher and more distant such clouds seem to be, the more gradual, but general, the coming change of weather will prove.

Light, delicate, quiet tints or colors, with soft, undefined forms of clouds, indicate and accompany fine weather; but gaudy or unusual hues, with hard, definitely outlined clouds, foretell rain, and probably strong wind.

Misty clouds forming, or hanging on heights, show wind and rain coming—if they remain, increase, or descend. If they rise or disperse, the weather will improve or become fine.

When sea birds fly out early, and far to seaward, moderate wind and fair weather may be expected; when they hang about the land, or over it, sometimes flying inland, expect a strong wind with stormy

* A "high dawn" is when the first indications of daylight are seen above a bank of clouds. A "low dawn" is when the day breaks on or near the horizon, the first streaks of light being very low down.

† In the tropics, or regions of trade winds, there is generally an upper and counter current of air, with very light clouds, which is not an indication of any approaching change. In middle latitudes such upper currents are not so frequent (or evident?) except before a change of weather.

weather. As many creatures besides birds are affected by the approach of rain or wind, such indications should not be slighted by an observer who wishes to foresee weather.

There are other signs of a coming change in the weather known less generally than may be desirable, and therefore worth notice; such as when birds of long flight, rooks, swallows, or others, hang about home, and fly up and down or low—rain or wind may be expected. Also, when animals seek sheltered places, instead of spreading over their usual range; when pigs carry straw to their sties; when smoke from chimneys does not ascend readily (or straight upwards during calm), an unfavorable change is probable.

Dew is an indication of fine weather; so is fog. Neither of these two formations occurs under an overcast sky, or when there is much wind. One sees fog occasionally rolled away, as it were, by wind—but seldom or never formed while it is blowing.

Remarkable clearness of atmosphere near the horizon, distant objects, such as hills, unusually visible, or raised (by refraction),* and what is called "a good hearing day," may be mentioned among the signs of wet, if not wind, to be expected.

More than usual twinkling of the stars, indistinctness or apparent multiplication of the moon's horns, haloes, "wind dogs"† and the rainbow, are more or less significant of increasing wind, if not approaching rain, with or without wind.

Near land, in sheltered harbors, in valleys, or over low ground, there is usually a marked diminution of wind, during part of the night, and a dispersion of clouds. At such times an eye on an overlooking height may see an extended body of vapor below (rendered visible by the cooling of night) which seems to check the wind.

Lastly, the dryness or dampness of the air, and its temperature (for the season), should always be considered, with other indications of change, or continuance of wind and weather.

* Much refraction is a sign of easterly wind.

† Fragments or pieces (as it were) of rainbows (sometimes called "wind-galls") seen on detached clouds.

Enameling Iron.

From the London Chemical News, No. 118.

Enameling iron is almost a new art. No metal is capable of receiving a coating of vitrified porcelain or enamel unless it is capable of withstanding a red heat in a furnace. Articles of cast iron, as a preparation for enameling, are first heated to a low red heat in a furnace, with sand placed between them, and they are kept at this temperature for half an hour, after which they must be allowed to cool very slowly, so as to anneal them. They are then subjected to a scouring operation with sand in warm dilute sulphuric or muriatic acid, then washed and dried, when they are ready for the first coat of enamel. This is made with six parts, by weight, of flint glass broken in small pieces, three parts of borax, one of red lead, and one of the oxide of tin. These substances are first reduced to powder in a mortar, then

subjected to a deep red heat for four hours in a crucible placed in a furnace, during which period they are frequently stirred, to mix them thoroughly; then toward the end of the heating operation the temperature is raised, so as to fuse them partially, when they are removed in a pasty condition and plunged into cold water. The sudden cooling renders the mixture very brittle and easily reduced to powder, in which condition it is called frit. One part of this frit, by weight, is mixed with two parts of calcined bone dust, and ground together with water until it becomes so comminuted that no grit will be sensible to the touch when rubbed between the thumb and the finger. It is then strained through a fine cloth, and should be about the consistency of cream. A suitable quantity of this semi-liquid is then poured with a spoon over the iron article, which should be warmed to be enameled, or if there is a sufficient quantity the iron may be dipped into it and slightly stirred, to remove all air bubbles and permit the composition to adhere smoothly to the entire surface. The iron article thus treated is then allowed to stand until its coating is so dry that it will not drip off, when it is placed in a suitable oven, to be heated to 180 deg. Fah., where it is kept until all the moisture is driven off. This is the first coat; it must be carefully put on, and no bare spots must be left on it. When perfectly dry the articles so coated are placed on a tray separate from one another, and when the muffle in the furnace is raised to a red heat they are placed within it and subjected to a vitrifying temperature. The furnace used is similar to that used for baking porcelain. This furnace is open for inspection, and when the enamel coat is partially fused the articles are withdrawn and laid down upon a flat iron plate to cool, and thus they have obtained their first coat of dull white enamel, called biscuit. When perfectly cool they are wetted with clean soft water, and a second coat applied like the first, but the composition is different, as it consists of thirty-two parts by weight of calcined bone, sixteen parts of china clay, and fourteen parts of feldspar. These are ground together, then made into a paste, with eight parts of carbonate of potash dissolved in water, and the whole fired together for three hours in a reverberating furnace; after which the compound thus obtained is reduced to frit, and mixed with sixteen parts flint glass, five and a half of calcined bone, and three of calcined flint, and all ground to a creamy consistency, with water, like the preparation for the first coat. The articles are treated and fired again, as has been described in the preparation coat, and after they come out of the furnace they resemble white earthenware. Having been twice coated, they now receive another coat and firing, to make them resemble porcelain. The composition for this purpose consists of four parts by weight of feldspar, four of clear sand, four of carbonate of potash, six of borax, and one each of oxide of tin, nitre, arsenic, and fine chalk. These are roasted and fritted as before described, and then sixteen parts of it are mixed with the second enamel composition described, excepting the sixteen parts of flint glass, which is left out. The application and firing are performed as in the other two operations, but the heat of vitrification is elevated so as to fuse the third

and second coats into one, which leaves a glazed surface, forming a beautiful white enamel. A fourth coat, similar to the third, may be put on if the enamel is not sufficiently thick. The articles may be ornamented like china ware, by painting colored enamels on the last of the coats, and fusing them on in the furnace. A blue is formed by mixing the oxide of cobalt with the last named composition; the oxide of chromium forms a green, the peroxide of manganese makes a violet, a mixture of the protoxide of copper and red oxide of lead a red, the chloride of silver forms a yellow, and equal parts of the oxide of cobalt, manganese, and copper form a black enamel when fused. The oxide of copper for red enamel is prepared by boiling equal weights of sugar and acetate of copper in four parts of water. The precipitate which is formed after two hours moderate boiling is a brilliant red. The addition of calcined borax renders all enamels more fusible.—*Engineer.*

Translated for the Journal of the Franklin Institute.

Improvements in the Refining of Sugars.

MM. Leplay and Cuisinier communicated to the Academy of Sciences of Paris, at their session on the 10th of February, 1862, a new mode of purifying saccharine liquids and syrups, and a new means of reviving the animal charcoal employed in the manufacture of sugar.

"In the ordinary process, a filter filled with the charcoal in grain, lasts from 12 to 24 hours; after this time, all its absorbing properties appear to be destroyed, and it must be revived, the principal operation of which is calcination in closed vessels, at a high temperature. Thus revived, however, it has not recovered its original properties completely, and its absorbing power is reduced one-half or even more."

"It is generally believed that all the absorbing powers of the charcoal are destroyed at once, and that the method of reviving restores them all at the same time. The fundamental idea of our method, on the other hand, consists, first, in our having discovered various absorbing powers, and different functions, in the charcoal in grains, which are exercised independently of each other, and are not simultaneously exhausted; secondly, in the successive reviving of these absorbing powers, in proportion as they are exhausted, by different means appropriate to the matters absorbed; thirdly, in the power of increasing at will the energy of the absorption, and thus rendering the purification of the syrups more complete; fourthly, in the disuse of any temperature above that of boiling water."

"By examining what takes place in the filtration of syrups, we have found, contrary to what is generally supposed, that the exhaustion of the absorbing powers of the charcoal may be divided into three periods, which we will examine successively."

"The first series of absorbing powers is nearly exhausted, under ordinary circumstances, in about four hours. These are the powers of absorption of viscous, azotized ammoniacal, sapid and odorous substances, which injure the fluidity of the syrups, their crystallization,

the firmness of grain, and the quantity and quality of the sugar, and which give to the crude sugar their peculiar odor and taste. We re-establish these absorbing powers completely, by passing a current of steam through the charcoal in the filter, and this may be done an indefinite number of times."

"The second series of absorbing powers of the charcoal requires a much longer time for their exhaustion, lasting six or eight times longer than the first. This exhaustion varies with the alkalinity of the defecated syrups. They are the absorbing powers for the free alkalies, potassa, soda, lime, and for salts. These matters especially contribute to the color of the syrups during the evaporation, and destroy the sugar; and when they exist in too great quantity, they prevent the obtaining of the proper degree of boiling for the crystallization. We revive these absorbing powers by a weak solution of chlorhydric acid poured on the filter, and by washing with water for a sufficient time."

"The third series comprises the absorbing power for coloring matters. They last thirty or forty times as long. Besides, the presence of these matters is not of so much importance when the syrups are transparent and brilliant, and contain no material in suspension. With colored syrups, white sugar may be obtained. When we judge it necessary to revive the absorptions, we do so by a weak boiling solution of caustic alkalies."

"All these operations are performed either on the filters themselves, or in apparatus similar to them."

"These different modes of revivification restore the absorbing power of the animal charcoal entirely, but without increasing it. We then sought, in the production of a new substance, fixed in the charcoal itself, the solution of the problem of the increase of the absorbing powers of the charcoal. When we put in a test-glass an equivalent of bi-phosphate of lime, and an equivalent of the tribasic phosphate, identical with that which enters into the composition of animal charcoal, the two combine to form a third, which is a phosphate with two equivalents of base, as is explained by the following formula:—

$$P O_5\ 3\,Ca\,O + P O_5\ Ca\,O\ 2\,H\,O = 2\,(P O_5\ 2\,Ca\,O\ H O).$$

"This phosphate is insoluble in water, without acid action on litmus-paper, produces no inversion in sugar, and possesses most powerful absorbing powers. That which is produced in the test-glass, may be done in the same way in a filter containing animal charcoal in grain, by pouring into it a dilute solution of bi-phosphate of lime. The same effect is produced on the charcoal in powder. Animal charcoal thus treated possesses much greater absorbing powers, which can be modified at will, and produce a much more complete purification in the syrups."

"We have also utilized, in the clarification and purification of saccharine liquids, the singular property which the phosphate with three equivalents of lime possesses, of forming a gelatinous precipitate which entangles in its meshes all the matters which trouble the transparency of the syrups much more completely than albumen, blood, or other materials used for clarification."

"The above methods are now in use in two important sugar establishments, and the quantity of sugar made by them up to this time is about 300 tons. They can be applied with equal success in the manufacture and refining of sugar from the cane."—*Cosmos.*

On the Maximum Density of Sea Water. By M. V. NEUMANN.

From the Lond. Ed. and Dub. Phil. Mag., November, 1861.

Von Neumann, in an inaugural dissertation (Munich, 1861), has published a new determination of the maximum density of sea water. Like Kopp and other physicists, who have made this determination for pure water, he measured the volume at different temperatures in a glass vessel, analogous in construction to a thermometer, the co-efficient of expansion of the glass being carefully determined. This method is well adapted for liquids whose freezing point is above the point of greatest density. The sea water used was obtained from Trieste, Genoa, and Heligoland, and was previously well mixed. Its freezing point was found to be —2·6° C., and its specific gravity at 0° C. 1·0281; its point of greatest density was —4·7364° C.

This number is more than that obtained by Despretz (—3·67°C. for sea water of 1·0273 sp. gr.) and Erman (—3·75° C.), but would probably agree with that of Marcet (—5·25°C.) and Horner (—5·56°C.), if a correction for the expansion of glass were introduced.—Poggendorff's *Annalen*, August, 1861.

Resistance of Square Bars to Torsion. By W. J. MACQUORN RANKINE.

From the Civ. Eng. and Arch. Jour., March, 1862.

SIR—It is very desirable that the attention of writers on the strength of materials should be called to the theoretical investigations of M. de St. Venant, especially those on torsion, which were published in the "*Mémoires des Savans Etrangers*," vol. xiv., about six years ago, but appear to have been almost wholly overlooked, although some of their results are of much practical importance.

According to the ordinary theory of the torsion of a straight uniform bar, each originally plane section perpendicular to the axis, continues to be plane and perpendicular to the axis when the bar is twisted. It is easy to see that this supposition is rigorously exact for a cylindrical bar only; but it seems to have been generally taken for granted that the errors to which it leads when applied to bars of other forms are unimportant in practice. M. de St. Venant shows that they are of importance; and, by a very skilful and laborious mathematical investigation, he obtains approximate formulæ in which allowance is made for the effect of what he calls the "gauchissement" (which may be translated the *warping*) of the originally plane cross-sections of bars that are not cylindrical. He arrives at the result, that the whole

of the ordinary formulæ relating to torsion are erroneous, except those for cylindrical bars.

The most important case in practice to which the method of M. de St. Venant has been applied, is that of a square bar, wrenched asunder by torsion.

Let h denote the side of the bar; f, the modulus of rupture by wrenching, or greatest intensity of the stress when the bar gives way; then the moment M of the force required to wrench asunder the bar is,

According to the ordinary formula, $M = \cdot 2357 f h^3$;
According to the improved formula, $M = \cdot 281 f h^3$.

In the reduction of experiments on wrenching equal bars asunder, the following are the values of the modulus f:

$$\text{According to the ordinary formula, } f = \frac{M}{\cdot 2357 h^3};$$

$$\text{According to the improved formula, } f = \frac{M}{\cdot 281 h^3}.$$

To these may be added the corresponding formula for cylindrical bars, in which alone M. de St. Venant makes no alteration,

$$f = \frac{M}{\cdot 196 h^3}.$$

An easy test of the accuracy of the formulæ for square bars is to try whether, when applied to experiments, they give values of f agreeing, or nearly agreeing, with those deduced from experiments on round bars. I have lately applied that test to them by the aid of the experiments of Mr. George Rennie and Messrs. Bramah on square bars of cast iron, and Mr. Dunlop on round bars of the same metal, as quoted by Mr. Hodgkinson in his work on Cast Iron (articles 201 to 204 inclusive), with the following results. (See also, as to Mr. Dunlop's experiments, Tredgold on Cast Iron, page 98.

	Modulus of Wrenching, f.	
	Ordinary formula.	M. de St. Venant's formula.
Square Bars.	lbs. on the sq. in.	lbs. on the sq. in.
Mean of Mr. Rennie's experiments, .	32,227	27,070
Mean of Messrs. Bramah's experiments,	37,747	28,640
General mean, . .	34,987	27,855
Cylinders.		
Mean of Mr. Dunlop's experiments, .	27,534	27,534
Difference, . .	7,453	321

It is obvious that the difference between the results of experiments on square and round bars, according to M. de St. Venant's formula,

falls within the limits of the ordinary variations of experiments on the strength of materials; which limits it greatly exceeds when the ordinary formula is applied.

GLASGOW, 4th February, 1862.

A Description of a Steam Hammer for Light Forgings. By Mr. RICHARD PEACOCK, of Manchester.

From Newton's London Journal, Aug., 1861.

Power hammers are almost indispensable for the production of sound smiths forgings, and their extensive introduction into the smithery has been attended with most valuable results. Their application is not of recent date, but the extraordinary demand for forged iron work for steamboat and railway work has given an impetus to their use, and their adaptation to the more general wants of the smith's shop is marked by great advantage as regards both efficiency and expedition.

The steam hammer described in the present paper, is now in use at the author's works, Gorton Foundry, Manchester; and is brought before the meeting by request, as an example of a practical and useful steam hammer for light forgings, heavy smith's work, stamping, &c. This hammer is worked by hand, and is either single or double acting; that is, it can either be lifted by steam and allowed to fall by gravity alone, or, after it has been lifted, steam can be used above the piston to give increased effect to the blow.

The steam cylinder is 10 inches diameter, and constructed for a 24 inch stroke. The valve is cylindrical, turned to fit well in the valve chest, but to move easily within it. The top end of the valve is made longer on one side than on the other, and, in one position, therefore, of the valve, steam is admitted above the piston in the down stroke, but by turning the valve half round, by means of a handle, the additional lap is brought into use, which prevents the admission of steam above the piston, and allows the hammer to fall by gravity alone. The valve is worked up and down by a hand lever; it is open through the centre, and the weight of the valve, valve rod, and hand lever, is counterbalanced by a spiral spring. To prevent the piston from rising too high in the cylinder, a trigger is fixed on the side frame, which when struck by a roller on the hammer block, lowers the valve, and allows the steam to escape from beneath the piston.

The piston is secured to the rod in the usual way by a cone and nut. The bottom end of the rod has a solid head, by which it is secured to the hammer block. This head is rounded on the top and bottom, and is made $\frac{1}{4}$ inch less in diameter than the hole in the hammer block, to allow of any twist or vibration, and prevent the breaking of the piston rod, which, from the oblique strain due to the varied character of the forgings, has hitherto given great trouble in steam hammers. The weight of the piston, piston rod, and hammer block, is $12\frac{1}{2}$ cwts., or 1400 lbs.

From diagrams which the author exhibited, the mean pressure of steam in lifting the hammer was shown to be 25·7 lbs. per square inch,

which, multiplied by 66 square inches area of the lower side of the piston, is equal to 1696 lbs. total; and the mean back pressure against the hammer when falling, including cushioning, was 4·3 lbs. per square inch, or 284 lbs. total. A partial vacuum was formed above the piston in falling, equal to 1·6 lbs. per square inch, or 126 lbs. total on 78·5 square inches area of the top of the piston; this added to the back pressure below the piston, gives a total retarding pressure of 410 lbs. to be deducted from the weight of the hammer. Thus the effective weight of the hammer is 1400 lbs. less 410 lbs., or 990 lbs.; say 9 cwts., or 29 per cent. less than the real weight of the falling mass. This weight multiplied by the height of the fall, 20 inches, gives an effective blow of 1650 lbs., or 14¾ cwts. falling one foot: friction not being taken into account.

Diagrams taken below the piston when steam was used above, the hammer working with the same stroke of 20 inches at 112 blows per minute, showed the mean pressure in lifting the hammer to be equal to 30·1 lbs. per square inch, or 1987 lbs. total; and the mean back pressure when the hammer was falling, 5·4 lbs. per square inch, or 356 lbs. total. Diagrams taken above the piston when steam was used above, the hammer working as before, with a stroke of 20 inches at 112 blows per minute, gave the mean pressure of steam during the down stroke 32·1 lbs. per square inch, or 2520 lbs. total; and the mean back pressure above the piston when rising, 8·8 lbs. per square inch, or 691 lbs. total. Hence the effective pressure of the steam on the top of the piston, was 2520 lbs. less a back pressure of 356 lbs., or 2164 lbs.; which, added to the weight of the hammer, gave a total effective weight of 3564 lbs., or 31¾ cwts. This weight multiplied by the height of the fall, gives an effective blow of 5940 lbs., or 53 cwts. falling one foot, when the steam is admitted above the piston; which compared with the blow of 14¾ cwts. when the hammer falls by its weight alone, shows an advantage of 3½ to 1.

Diagrams taken below the piston with the hammer making a stroke of 10 inches and 117 blows per minute, and falling by gravity alone, gave an effective action calculated as in the preceding case, equal to 709 lbs., or 6¼ cwts. falling one foot. When steam was used above the piston, the hammer working with the same stroke of 10 inches at 150 blows per minute, the effect given by the diagrams was equal to 2396 lbs., or 21½ cwts. falling one foot; showing a superiority of 3¼ to 1 over the hammer falling by gravity alone.

Diagrams taken below the piston, the hammer working with a stroke of 5 inches, at 147 blows per minute, and falling by gravity alone, gave an effect equal to 380 lbs., or 3½ cwts. falling one foot. Others taken below and above the piston when steam was used above, the hammer working with the same stroke of 5 inches at 180 blows per minute, gave a result equal to 1149 lbs., or 10¼ cwts. falling one foot; showing an advantage of 3 to 1 over the hammer falling by gravity alone.

The Chairman observed, there appeared to be two points particularly to be noticed in the hammer just described:—the simple mode of

altering the lap of the valve by the use of a cylindrical valve that could be turned round by hand into any position between the two extremes of no lap or full lap; and the ingenious mode of attaching the piston rod to the hammer block for overcoming the difficulty experienced in previous hammers from breakage of the piston rod. He inquired how many of the hammers were now at work, and of what size, and what was the cost of the hammer.

Mr. Peacock replied that there were now three of the hammers at work, all of the size shown in the drawings, one of which had been working about eight months; the cost was about £175, exclusive of the anvil. He showed a full size specimen of the valve, and explained that it was worked by hand with the greatest ease, being made hollow for the steam to pass through, so that it was completely balanced; and having a lap half round the circumference at the top end, it could be turned round by hand, so as entirely to prevent the steam entering above the piston, for giving light finishing blows with the hammer. The chief object in the hammer was simplicity of construction, by the absence of gearing for working the valve; it was therefore not likely to get out of order, while the working was completely controlled by hand; and it was particularly serviceable for smith's work, where no two blows were wanted alike.

Mr. F. J. Bramwell had long been convinced that gravity alone was not sufficient for working steam hammers, because a great part of the effect was lost whenever the height of fall was diminished by having a large mass on the anvil. He had aided in devising a steam hammer some years ago for crushing ore, and also for forging iron; the falling weight was 30 cwts., but by using steam on the top of the piston, the force of blow of a large hammer was got out of a small one, with a rapidity of stroke that could not be attained by gravity alone. The piston rod was made very large, half the area of the piston, so that the steam had only the annular area to lift by; and for the down stroke the steam was exhausted from the bottom of the cylinder into the top, where it acted upon the whole area of the piston, producing a total effective pressure corresponding to half the area. Two of these hammers had been put to work at Rotherham, about six years ago, and continued working there satisfactorily. The principal difficulty he had experienced was in attaching the piston rod to the hammer block, which had been done in the first hammer with two keys driven in horizontally from each side, and with wood packing to produce a certain amount of elasticity; but the keys got loose with the jarring of the blows, and came out. To prevent this, they were then put in obliquely, inclined downwards, which caused them to remain secure; all elastic packing in the hammer block was abandoned, the keys being driven in tight to make a rigid attachment; and this plan succeeded entirely. The connexion of the piston also to the rod was frequently a difficulty, and he thought the best plan was to forge it solid on the rod, and make it steam-tight with Ramsbottom's packing rings, so as to have as light a packing ring as possible. Where a steam hammer was required, he doubted whether it was ever desirable

to work it without any steam on the top; but the valve now shown would be very useful for altering the degree of lap and varying the admission of steam above the piston. In the indicator diagram, the vacuum shown above the piston in falling when the hammer worked single-acting, seemed much less than he would have expected if there were no air drawn in except through leakages.

Mr. C. W. Siemens said, it seemed extraordinary there should be so small a vacuum above the piston, when no air or steam was admitted; but this might be explained by the circumstance that the surfaces of the cylinder remained wet from the preceding up stroke, and a generation of steam would take place from them as soon as the pressure fell below that of the atmosphere.

Mr. C. Markham inquired how the length of stroke of the hammer was varied. There was a great advantage in being able to use steam above the piston when required, but he did not think it was desirable to do so always, as there would then be a loss in working with a short range, because a whole cylinder full of steam would be thrown away at each stroke.

Mr. Peacock replied that the length of stroke was varied entirely by the hand lever, which could be done to a great nicety after a little practice.

Mr. E. A. Cowper observed that the loss of steam in working the hammer at a short range with steam above the piston would be greatly reduced by the plan mentioned by Mr. Bramwell, of enlarging the piston rod and using the same steam above the piston that had previously lifted the hammer; the additional work got out of the steam in the down stroke was then all gained. The indicator diagram, taken from the top of the cylinder when the hammer was working single-acting, showed the want of a steam jacket, by the fact of the pressure produced by generation of steam from the wet surface of the cylinder; and he believed all steam hammers required jackets quite as much as the cylinders of steam engines; for if there were any moisture on the surfaces of the cylinder, it showed that a quantity of steam was passing through without doing duty, being merely condensed in the cylinder and then evaporated again. He inquired why the back pressure below the piston was so high in all the diagrams, and suggested that it might be greatly diminished by making the middle of the valve half a port longer than the distance between the ports, so as to obtain a much more free exhaust: this plan he had carried out extensively in steam engines, with excellent effect.

Mr. Peacock replied that the greater part of the back pressure was due to the cushioning in the last portion of the stroke, as shown by the diagrams, and there was only a small back pressure in the previous portion of the stroke. Cushioning was necessary for lifting the hammer again more readily after the blow, and to insure lifting it clear without repetition of the blow. The addition of a steam jacket round the hammer cylinder would no doubt be desirable where economy of steam was of importance, though of course increasing the first cost to some extent; but, at his own works, the steam was not

considered an important item, as it was supplied from vertical boilers heated by the furnaces, and there was still steam blowing off while the hammer was at work.

He explained the mode of attaching the piston rod to the hammer block so as to make a good and durable connexion; the hammer block being made of wrought iron, with a bore hole carried right through, in order to get the boring bar in for boring the upper portion of the block. A hard wood packing of oak, teak, or ash, was inserted in the bottom of the block between two wrought iron washers, against which the bottom of the piston rod bore with a cheese head, $\frac{1}{4}$ inch smaller in diameter than the hole in the block; above the cheese head was another washer, and then two cotters, one on each side of the rod, which avoided weakening the rod by cutting cotter holes through it. The hammer was then put to work, and the cotters gradually tightened up; and after a week's work, new cotters were put in, slightly larger, so as to fit tight, which would then last for three or four months without any attention.

Mr. R. Williams inquired what sort of gland was used at the bottom of the cylinder, and what packing was employed for the piston.

Mr. Peacock replied that it was simply an ordinary stuffing-box at the bottom of the cylinder; the piston was made with two of Ramsbottom's packing rings, which would remain steam-tight for eighteen months or more without taking out, and he had had a Nasmyth hammer working with them for four years. He was now making a 4-ton hammer on this construction, in which the exhaust side of the valve would be made longer than the distance between the ports, in order to prevent a vacuum being formed above the piston in falling, when working single-acting, by allowing some of the exhaust steam from below the piston to pass into the top of the cylinder.

Mr. W. Naylor doubted whether the same accurate adjustment of the blow could be got in working the valve by hand as when gearing was used; in a rapid play of blows he thought the hammer would only just touch the anvil, without giving much force of blow, and the valve would have to be reversed some time before the piston reached the top of the cylinder, to prevent any chance of keeping the steam on too long. He had found the great desirability in a forge of having a hammer that could be worked single-acting or double-acting as required; for when the iron was brought under the hammer at a welding heat, it wanted quick light blows at first for welding it together, and then heavy blows for working it into shape, which could be done with a double-acting hammer at the same heat; and the fewer heats the work had to go through, the better and quicker it was done. He thought the valve described appeared similar to that in his own hammer, which had been described at a former meeting. He asked whether any breakage of the cotters in the hammer block had occurred since first starting.

Mr. Peacock replied that they had never had any cotters broken during eight months work, and the attachment of the piston rod and

hammer block continued perfectly fast. The valve was designed as a simple form of balanced valve, that could be cast all in one piece, and required only turning up on the outside without any fitting. For ordinary smiths work, the hammer was oftener wanted without the steam on the top than with it; but in forging work under dies, very heavy blows were required, and it was a great advantage then to have the means of increasing the force of blow with the same hammer. By dispensing with gearing for working the valve, the construction was much simplified, and the hammers were found to be handier for the men than a Nasymth 15 cwt. hammer worked by gearing in the same shop: the boys who worked the valves got quite perfect in managing them after three or four days practice, and gave exactly the force of blow that the smith directed.

Proc. Mech. Eng. Soc.

Oblique-Jointed Steam Boilers.

From the Lond. Mining Journal, No. 1306.

The absolute necessity of the highest attainable strength being secured for steam boilers is universally admitted; and that there was much room for improvement was proved by the experiments of Mr. William Fairbairn, having discovered that in cylindrical vessels subjected to internal pressure the strength in their longitudinal direction is twice that of the plates in their curvilinear direction, and that an ordinary riveted joint, of good proportions and workmanship, has but half the strength of the solid plate. Taking these facts into consideration, it is evident that (since the joints are but one-half the strength of the solid plate, and the transverse strength is considerably less than the longitudinal) it is of paramount importance to remove the necessity for longitudinal joints, for by that means the strength may be very materially increased without adding to the weight of the boiler. By an ingenious arrangement patented by Messrs. Wright and Co., of Goscote Works, Walsall, a stronger boiler is produced than has hitherto been practicable. The crossing of the joints has been much relied on, and doubtless it is highly beneficial; but in addition to this Messrs. Wright further increase the strength by arranging all the joints diagonally. In the patent boiler longitudinal joints are entirely dispensed with, and a system of equal oblique or diagonal joints adopted throughout. Its weaker section is altogether avoided by the lines of riveting; and the transverse or double strain, which in the common boiler acts only upon two opposite ends of the plates, in the patent boiler is distributed equally around them. By this diagonal arrangement of the joints, all the riveting of the boiler assists equally in supporting the transverse strain, instead of the longitudinal joints alone being left to contend with it, as in the common plan; and this is accomplished without any increase in the whole amount of riveting, except only when it may be required to give a surplus of strength to the joints, in which case less than 5 per cent. of additional riveting will suffice. And the patent boiler thus

made is preferable to any that might be made with welded joints, because more reliable; for the risk of imperfect welding would be greater than that of imperfect riveting. All the boilers constructed upon this principle are made to bear a pressure from six to nine times that at which it is to be worked, and every boiler is tested up to double the working pressure before it leaves the establishment.

Metallic Alloy.

From the Lond. Mining Journal, No. 1309.

Mr. Johann Aich, Venice, has patented some improvements in amalgamating metals, which consist in forming an alloy of—copper, 60lbs.; zinc, 38 lbs. 2 ozs.; and iron, 1 lb. 8 ozs. The zinc may be increased to 44 lbs., and the iron diminished to ½ lb. or increased 3 lbs. If the amalgamation of the parts be perfect, the product may be worked both hot and cold. At a red heat it is malleable like the best wrought iron, and may be beaten, stamped, or drawn. It is cheaper than brass, and may be advantageously substituted for brass and copper, and resists the action of sea water satisfactorily.

A New Fuel for the Navy.

From the London Mining Journal, No. 1355.

The great advantages of using large coal of high evaporative power for steam purposes generally, and more especially for marine purposes, is universally admitted; and it will consequently be gratifying to the shipping interest to learn that the Crown Preserved Coal Company's first year's operations have been of the most successful character. The blocks of fuel manufactured by this company are of the uniform size of 1 cubic foot, and of the uniform weight of 56 lbs.; whilst the space required for stowage is materially less.

To show the practical advantages of using preserved coal, the company quote an instance of a steam voyage to Rio Janeiro:—

"The quantity of coals to be taken from Southampton would be 1000 tons, at a cost of about £900, and occupying 1050 tons of space. On the other hand, 1000 tons of preserved coal would cost £100 more, but there would be a saving of 250 tons of space, which, at the usual rate of £6 per ton of freight, would produce £1500. This amount would not only pay for the preserved coal, but leave a surplus of £500 extra profit, merely for the outward voyage."

Amongst the other advantages claimed for the artificial fuel, as compared with ordinary coal, are the circumstances that by the process employed the fuel is made so dry that decomposition is arrested; that it is free from dust, and nearly as clean as blocks of stone; that it is not liable to spontaneous combustion, neither does it emit gas or smell of any kind, nor involve risk or injury of cargo, and that the evaporating power of the fuel is nearly 10 per cent. greater than any

other description of coal known. The fuel has been favorably reported upon by Commander Watson, of Her Majesty's ship *Royal Albert*, and has been extensively used by several of the large steam navigation companies.

On the Deficiency of Rain in an elevated Rain-Gauge, as caused by Wind. By W. S. JEVONS, B. A., of University College, London.

From the Lond. Edin. and Dub. Phil. Mag., December, 1861.

My conclusions, shortly stated, are:—

1. An increase of the rainfall close to the earth's surface is incompatible with physical facts and laws.

2. The individual observations on this subject are utterly discordant and devoid of law when separately examined, and the process of taking an average under such circumstances gives an apparent uniformity which is entirely fallacious.

3. When daily measurements of rain, or even monthly totals, are examined with reference to the strength of the wind at the time, it becomes obvious that there is a connexion.

4. Wind must move with increased velocity in passing over an obstacle. It follows demonstratively that rain-drops falling through such wind upon the windward part of the obstacle will be further apart, in horizontal distance, than where the wind is undisturbed and of ordinary velocity.

LONDON, August 28, 1861.

For the Journal of the Franklin Institute.

Armor-Clad Ships of War. By WM. H. SHOCK, Ch. Eng. U. S. N.

The late naval engagement between the *Monitor* and *Merrimac* in Hampton Roads, inaugurated a new and highly important change in naval warfare—a change destined to set aside our preconceived notions of what was supposed to be the perfection of war ships; indeed, so marked and immediate have been the modifications, if not the entire change of opinion on this subject at the Navy Department, that already workmen are busy in cutting down and in other respects preparing one of our first class steam frigates (the *Roanoke*) for the reception of an armor.

The idea of introducing iron ships for naval purposes originated in this country with the late R. L. Stevens, of New York, one of the most distinguished scientific gentlemen of his day, and by him suggested to the Government in 1841. It was not until 1854, however, that work on the present battery was commenced, and in twenty months it assumed its present advanced condition, since which time nothing has been done towards its completion; and it was reserved for the *Monitor* and her officers to be the first successfully to demonstrate, by a practical test of five hours desperate fighting (with an enemy worthy of her), that the day of wooden ships for war purposes had passed, and

henceforth *Monitors* and "*Enemy repulsed*" were to be synonymous terms.

England and France have not been slow to estimate the superiority of iron ships for war purposes; but with them, as with ourselves, there is a diversity of opinion as to the best plans, and as this question will have to be decided by experience and experiments, the inventive genius of the present age will have an ample field in that direction.

The English Government in 1855-6 built three armor-clad ships of war, the *Thunderbolt*, *Etna*, and *Terror*, from designs and under the direction of the Admiralty; they were intended especially for an attack on Cronstadt, but the war with Russia terminated before they were brought into active service. These appear to have been the first iron ships of war constructed by the English Government, and that they possessed in the principles of their construction many elements of success, I think will be proven by future experience.

A description of these ships, given before the Institution of Naval Architects by Mr. Samuda, on the 28th of February, 1861, will be found interesting:—

"They were 2000 tons burthen, and pierced for 30 guns; drew when ready for sea 8 feet 6 inches. The hulls were built *entirely of iron;* the top sides were then covered with teak 6 inches thick, and reached from the gunwale to about 2 feet below the deep water line, a distance of about 13 feet, and this teak was again covered with wrought iron armor plate averaging 4 inches in thickness, bolted against the teak and through it and the iron skin of the vessel. The armor reached from stem to stern, and thus protected the entire topside of the ship, and also two feet under the water."

The construction of the *Warrior* and *Black Prince* seems to have been the next decided step in the introduction of iron-clad ships of war in England, and exceeded in gigantic proportions in tonnage and general dimensions the *Thunderbolt* and her compeers, as will be seen from the following dimensions of the two ships, viz:—

Length,	380 feet.
Beam,	58 "
Depth of hold,	33 "
Tonnage,	6038 tons.

They were protected by 4½ inch armor plates for about 200 feet of their midship length, extending from gunwale to 5 feet below the water line, with 18 ins. of teak backing interposed between the armor plates and the skin of the ship, but the ends of the vessels were left unprotected. In this particular the *Warrior* and *Black Prince*, as well as the Philadelphia iron-clad vessel, are alike defective. The wonderful degree of accuracy obtained in heavy ordnance practice, renders it imperative that no vulnerable points be exposed.

The *Monitor*, *Galena*, and a third iron-clad vessel that I shall term the *Philadelphia Iron-clad*, were contracted for at the same time, all differing from each other in every particular. To the latter I propose to devote the remainder of this paper.

The *Philadelphia Iron-clad* is being built by and from designs of Messrs. Merrick & Sons, Southwark Foundry, Philadelphia.

The following are her dimensions:

HULL (wood).

Length,	232 feet.
" between perpendiculars,	230 "
Beam,	57 " 6 ins.
Depth of hold.	17 "
Tonnage by measurement,	3436 tons.
Draft of water at deep load line,	15 feet.
Displacement,	4120 tons.
Immersed sectional area,	809 sq. ft.
Immersed section per square foot of screw's disk,	6·09
Angle of entrance at load line,	92°
" departure,	166°
Area of immerged portion of hull,	16,325 sq. ft.
Weight of hull, *per se*,	2000 tons.
Estimated weight of armor,	750 "

Barque rigged.

BATTERY.

16 9-inch Dahlgren guns, eight on a side.

Weight of guns,	152,000 lbs.
" metal thrown at one broadside (shell),	592 "
" " " " " (shot),	800 "

ENGINES.

She is supplied with two horizontal, direct-acting engines.

Diameter of cylinders,	50 inches.
Stroke of piston,	30 "
Surface condensers—Condensing surface,	3000·3 sq. ft.
Diameter of air pumps,	12½ "
Stroke of "	30 "
Diameter of circulating pumps,	11 "
Stroke of "	30 "
Lap on steam valve, steam side,	1½ inches.
" " exhaust side,	¾ "

BOILERS.

She is furnished with four horizontal tubular boilers.

Heating surface to top of tube box,	8450 sq. ft.
Grate surface,	355 44 "
Ratio of grate to heating surface,	1 to 23·7.
Estimated consumption of coal per sq. ft. of grate per hour,	12·6 lbs.
" water evaporation per lb. of coal,	8·5.
" consumption of coal per 24 hours,	$48\frac{840}{2240}$.

Artificial draft.

PROPELLER.

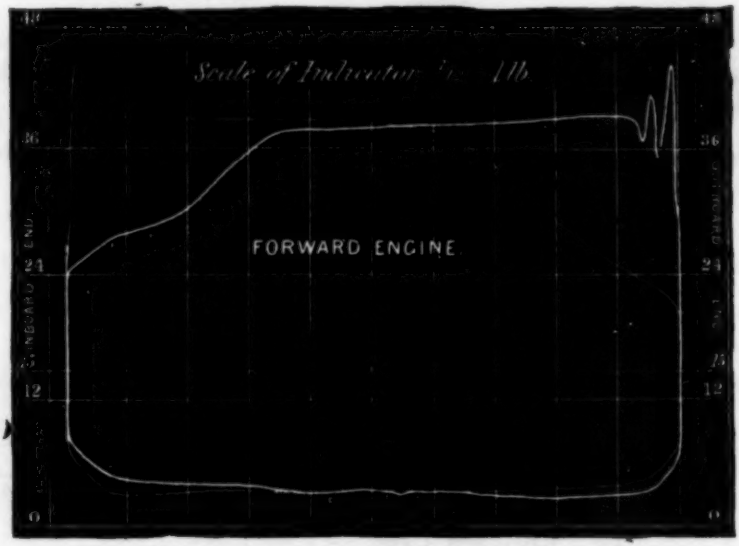
One composition screw.

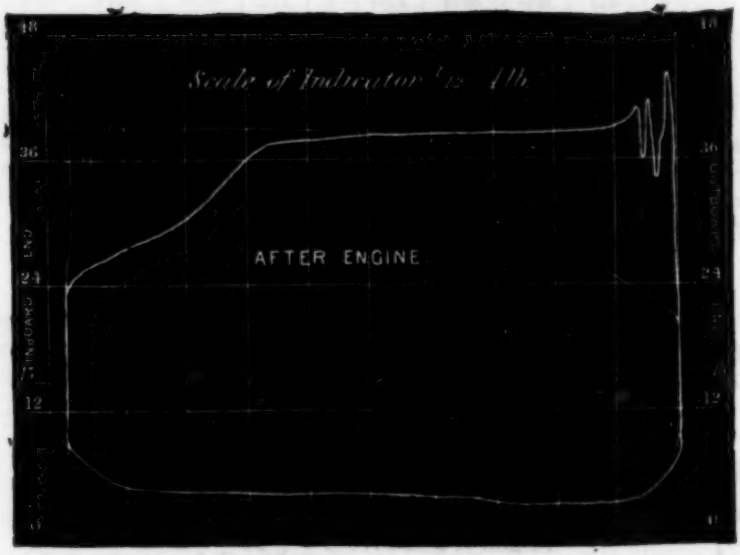
Number of blades,	4.
Diameter,	13 feet.
Pitch, 15 to 17 feet—mean,	16 "
Length,	29 inches.

Theoretical Disposition of Power of Engines and Speed of Ship under favorable circumstances.—Having the data necessary, the following engine diagrams are constructed, from which the estimated engine performance is deduced:

Pressure per gauge,	28 lbs.	Revolutions, . . .	80.
Vcauum " . .	26 "	Hotwell, . . .	110°.

Consumption of coal per hour, 4500 lbs.





The above diagrams show a mean effective pressure of 30·88 lbs. per square inch acting on the pistons, and using these figures with

the other data as shown by the diagrams, we have as the total developed power of the engines,

$$\frac{1963{\cdot}5 \times 30{\cdot}88 \times 400 \times 2}{33000} = 1470 \text{ H. P.}$$

From this H. P., however, the usual deductions are to be made before determining the actual engine power utilized in propelling the ship.

The power absorbed in overcoming cohesive resistance of water to the screw's passage through it, will be the first considered, and in doing which the following table is constructed:—

Engine Power Absorbed in Overcoming Resistance of Water to Screw's Passage through it.

Pitch, 15 + 17 ÷ 2 = 16 mean. Mean length, 2 ft. 5 ins. Fraction of pitch used, ·151. Revolutions per minute, 80.

No.	Pitch of element.	Radii of element in feet.	Cir normal to radii of element.	Length of element for one convolution of thread.	Length of element used.	Breadth of element.	Area of element.	Speed of element in feet per second.	Speed of element in feet per second.	Friction in pounds.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
1	16	1·0989	6·90	17·46	2·627	·8	2·101	23·2	1392·0	7,671·36
2	"	1·75	10·99	19·38	2·926	·5	1·463	25·64	1550·4	6,677·57
3	"	2·25	14·13	21·34	3·222	·5	1·611	28·45	1707·2	10,011·02
4	"	2·75	17·27	23·54	3·554	·5	1·777	31·38	1883·2	14,824·73
5	"	3·25	20·42	25·94	3·916	·5	1·958	34·68	2075·2	21,976·36
6	"	3·75	23·56	28·48	4·300	·5	2·150	37·64	2278·4	31,191·29
7	"	4·25	26·70	31·12	4·699	·5	2·349	41·36	2489·6	44,787·80
8	"	4·75	29·84	33·85	5·111	·5	2·555	45·13	2708·0	66,367·20
9	"	5·25	32·98	36·65	5·534	·5	2·767	48·85	2932·0	87,048·14
10	"	5·75	36·12	39·50	5·964	·5	2·982	52·66	3160·0	117,552·60
11	"	6·25	39·27	42·21	6·403	·5	3·201	56·28	3376·8	154,215·84
							24·914			561,723·31

From the above table it will be observed that the total area of elements for one side of one blade is 24·914, and 24·914 × 4 = 99·65 sq. feet, the total area of all the elements used. It will also be observed from column 10, that the surface resistance in pounds for one side of one blade is 561723·31, and

$$\frac{561723{\cdot}31 \times 2 \times 4}{33000} = 136{\cdot}175 \text{ H. P.}$$

From which a deduction is to be made for the rounding of the corners of the blades equal to an area of 6 sq. ft., and having a velocity due to the outer element as follows:

$$\frac{42{\cdot}21 \times 80}{60} = 56{\cdot}28,$$

the speed per second of the outer elements;

and $10^2 : 56{\cdot}28^2 :: {\cdot}45 : 14{\cdot}253$, = the lbs. per sq. ft.,

and $$\frac{14{\cdot}253 \times 6 \times 3376{\cdot}8}{33000} = 8{\cdot}75 \text{ H. P.}$$

and $136{\cdot}175 - 8{\cdot}75 = 127{\cdot}32$ H. P.

ERRATA.

The reader will please erase the second line from the bottom of page 336, and insert the following:—

and $$\frac{14{\cdot}253 \times 6 \times 2\,(\text{two sides}) \times 3376{\cdot}8}{33000} = 17{\cdot}50 \text{ H. P.}$$

This increases the H. P. utilized in propelling the ship to 740·645, and reduces the H. P. required to overcome cohesive resistance of water to screw's passage through it, to 118·675.

utilized in propelling ship,	731·9	"	53·24 "
	1374·9	"	100 "

Estimated Speed of Ship under favorable circumstances.—Allowing 80 revolutions of screw per minute, with a mean pitch of 16 feet and 30 per cent. slip, we have for the speed of the ship as follows:

$$\frac{80 \times 60 \times 16 \times {\cdot}70}{6080} = 8{\cdot}84 \text{ knots per hour.}$$

On the Effect of the Presence of Metals and Metalloids upon the Electric Conducting Power of Pure Copper. By A. Matthiessen, Ph. D., and M. Holzmann, Ph. D. Communicated by Professor Wheatstone, F. R. S.

From the Lond. Artizan, Nov., 1860.

As the electric conducting power of copper varies so much according to different experimenters, we thought it would be of some interest to study the causes of these differences; and on comparing the values found for copper, we find that, taking silver = 100, copper conducts according to

Becquerel,*	95·3	Harris,§	100·0
Riess,†	67·2	Buff,‖	95·4
Lenz,‡	73·4	Pouillet,¶	73·0
Davy,§	91·2	Arndtsen,**	98·7
Christie,§	66·0		

The temperatures at which the above observations were made are only given in the cases of Becquerel, Lenz, and Arndtsen, who compared copper at 0° C. with silver at 0° C. = 100.

We prepared therefore pure copper,—

1. By precipitating with sulphuretted hydrogen the purest commercial sulphate of copper dissolved in water acidulated with sulphuric acid, dissolving the washed sulphide in nitric acid, precipitating at a

* Ann. de Chim. et de Phys., Ser. 3, vol. xvii., p. 242.
† Poggendorff's Annalen, vol. xlv., p. 20.
‡ Gmelin, vol. i., p. 289.
¶ Muller, Lehrbuch, der Physik, p. 202.
‖ Ibid. p. 105.
‖ Buff, Grundriss, der Physik, 348.
** Poggendorff's Annalen, vol. cv., p. 1.

Revolutions per minute, 80.

No.	Pitch of element.	Radii of element in feet.	Circ normal to radii of element.	Length of element for one convolution of thread.	Length of element used.	Breadth of element.	Area of element.	Speed of element in feet per second.	Speed of element in feet per second.	Friction in pounds.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
1	16	1·0989	6·90	17·46	2·627	·8	2·101	23·2	1392·0	7,671·36
2	"	1·75	10·99	19·38	2·926	·5	1·463	25·64	1550·4	6,677·57
3	"	2·25	14·13	21·34	3·222	·5	1·611	28·45	1707·2	10,611·02
4	"	2·75	17·27	23·54	3·554	·5	1·777	31·38	1883·2	14,824·73
5	"	3·25	20·42	25·94	3·916	·5	1·958	34·68	2075·2	21,976·36
6	"	3·75	23·56	28·48	4·300	·5	2·150	37·64	2278·4	31,191·29
7	"	4·25	26·70	31·12	4·699	·5	2·349	41·36	2489·6	44,787·80
8	"	4·75	29·84	33·85	5·111	·5	2·555	45·13	2768·0	66,367·20
9	"	5·25	32·98	36·65	5·534	·5	2·767	48·85	2932·0	87,048·14
10	"	5·75	36·12	39·50	5·964	·5	2·982	52·66	3160·0	117,552·00
11	"	6·25	39·27	42·21	6·403	·5	3·201	56·28	3376·8	154,215·84
							24·914			561,723·31

From the above table it will be observed that the total area of elements for one side of one blade is 24·914, and $24·914 \times 4 = 99·65$ sq. feet, the total area of all the elements used. It will also be observed from column 10, that the surface resistance in pounds for one side of one blade is 561723·31, and

$$\frac{561723·31 \times 2 \times 4}{33000} = 136·175 \text{ H. P.}$$

From which a deduction is to be made for the rounding of the corners of the blades equal to an area of 6 sq. ft., and having a velocity due to the outer element as follows:

$$\frac{42·21 \times 80}{60} = 56·28,$$

the speed per second of the outer elements;

and $10^2 : 56·28^2 :: ·45 : 14·253$, = the lbs. per sq. ft.,

and $$\frac{14·253 \times 6 \times 3376·8}{33000} = 8·75 \text{ H. P.}$$

and $136·175 - 8·75 = 127·32$ H. P.

the total labor of the engine absorbed in overcoming the cohesive resistance of the water to the screw's passage through it.

The following is a general synopsis of the other deductions or theoretical disposition of the power of the engines:

Total horse power developed, .	1470·00	or 100	per cent.
Horse power to work engines (*per se*) .	95·10	" 6·47	"
	1374·9		
Horse power transmitted to screw shaft,	1374·9	or 100	per cent.
" required to overcome friction of load,	103·11	or 7·5	"
" " " cohesive resistance of water to screw's passage through it, .	127·425	" 9·26	"
" expended in slip of screw,	412·47	" 30	"
" utilized in propelling ship,	731·9	" 53·24	"
	1374·9	" 100	"

Estimated Speed of Ship under favorable circumstances.—Allowing 80 revolutions of screw per minute, with a mean pitch of 16 feet and 30 per cent. slip, we have for the speed of the ship as follows:

$$\frac{80 \times 60 \times 16 \times \cdot 70}{6080} = 8\cdot 84 \text{ knots per hour.}$$

On the Effect of the Presence of Metals and Metalloids upon the Electric Conducting Power of Pure Copper. By A. Matthiessen, Ph. D., and M. Holzmann, Ph. D. Communicated by Professor Wheatstone, F. R. S.

From the Lond. Artizan, Nov., 1860.

As the electric conducting power of copper varies so much according to different experimenters, we thought it would be of some interest to study the causes of these differences; and on comparing the values found for copper, we find that, taking silver = 100, copper conducts according to

Becquerel,* . .	95 3	Harris,§ . .	100·0
Riess,† . . .	67·2	Buff,‖ . . .	95·4
Lenz,‡ . . .	73·4	Pouillet,¶ . .	73·0
Davy,§ . . .	91·2	Arndtsen,** .	98·7
Christie,§ . .	66·0		

The temperatures at which the above observations were made are only given in the cases of Becquerel, Lenz, and Arndtsen, who compared copper at 0° C. with silver at 0° C. = 100.

We prepared therefore pure copper,—

1. By precipitating with sulphuretted hydrogen the purest commercial sulphate of copper dissolved in water acidulated with sulphuric acid, dissolving the washed sulphide in nitric acid, precipitating at a

* Ann. de Chim. et de Phys., Ser. 3, vol. xvii., p. 242.
† Poggendorff's Annalen, vol. xlv., p. 20.
‡ Gmelin, vol. i., p. 289.
¶ Muller, Lehrbuch, der Physik, p. 202.
‡ Ibid, p. 105.
‖ Buff, Grundriss, der Physik, 348.
** Poggendorff's Annalen, vol. cv., p. 1.

boiling temperature by carbonate of soda in excess, and finally reducing the oxide of copper with pure hydrogen.

2. By precipitating sulphate of copper galvanoplastically by a very weak current.

We have also tested the galvanoplastic copper of commerce, and have found that its conducting power is the same as that of the copper we prepared.

The method used for the determinations was the same as that described in the *Philosophical Magazine* (February, 1857). The diameters of the wires used were about 0·25 to 0·5 millim., and the lengths from 0·5 to 1·5 metre; and of each specimen of copper or alloy two or three determinations were made with wires of different diameters.

The following are the results obtained with pure copper, compared with a hard drawn silver wire = 100 at 0° C. (all the wires were hard drawn):—

		Means.
I. Copper purified by the above method (1),	*a.* 92·63 at 18·0 *b.* 93·36 at 19·2	93·00 at 18°·6.
II. Copper, galvanoplastic, not fused,	*a.* 93·81 at 19·7 *b.* 93·56 at 20·5 *c.* 93·00 at 20·4	93·46 at 20·2.
III. Copper, galvanoplastic commercial, not fused,	*a.* 92·24 at 18·0 *b.* 93·01 at 18·5 *c.* 93·81 at 18·7	93·02 at 18·4.
IV. Copper, No. 3, fused in a porcelain tube in hydrogen,	*a.* 92·22 at 19·3 *b.* 93·30 at 19·3	92·76 at 19·3.
V. Copper, No. 3, fused, as will be presently described,	*a.* 92·57 at 17·8 *b.* 93·40 at 17·2	92·99 at 17·5.

The mean of the above twelve determinations gives 93·08 at 18·9° for the conducting power of pure copper.

Peltier* and others have already observed that annealed copper wire conducts better than hard drawn wire; and on repeating the experiments with hard drawn wires from copper No. 2, and which were annealed in a current of pure hydrogen, we found the following numbers:—

I. Hard drawn,	95·31 at 11·0°
Annealed,	97·83 at 11·0
II. Hard drawn,	95·72 at 11·0
Annealed,	98·02 at 11·0

which makes a difference in the conducting powers of hard drawn and annealed wires of about 2·5 per cent.; much greater, however, is the difference between hard drawn and annealed silver wires, as the following experiments show:—

I. *a.* Hard drawn,	95·28 at 14·6°
b. Annealed,	103·98 at 14·8
II. *a.* Hard drawn,	95·36 at 14·6
b. Annealed,	103·33 at 14·6

We will now proceed to describe what is the effect of the metal-

* Ann. de Chim. et de Phys., lvi., p. 371.

loids, and afterwards of the metals, on the conducting power of copper.

1. *Effect of Oxygen (Suboxide of Copper).*

Copper readily absorbs oxygen from the air when in a fused state; and it is supposed to be present as suboxide, which it retains very obstinately; and in fact we may lead hydrogen over fused copper, in a porcelain tube, for hours without completely reducing the suboxide. It is also very difficult to prevent the oxygen being absorbed during casting, &c. In order to prevent all these sources of error, we thought that in making the alloys of copper by the following method, we might obviate them:—

In the furnace door communicating with a closed muffle are two holes; through the upper one passes a glass tube connected with a carbonic acid gas apparatus, and through the lower one passes a clay tobacco-pipe, to the stem of which is joined the bottle evolving hydrogen. The hydrogen is washed with potash, nitrate of silver, and concentrated sulphuric acid, and the carbonic acid gas with bicarbonate of potash and strong sulphuric acid. The metal (about 8 grms. were taken for each experiment) was placed in the bowl of the pipe, and so fused in a current of hydrogen; when fused, the hydrogen bubbled up through the melted metal; thus by offering a fresh surface to the hydrogen, any suboxide that might be present was reduced, and when making the copper alloys complete mixture was effected. When the hydrogen had passed through for a certain length of time, the india rubber tubing was disconnected from the sulphuric acid bottle, and the fused metal carefully sucked into the pipe-stem, forming a wire which might, if necessary, be drawn finer. The carbonic acid gas was used to help to drive the air out of the muffle, as well as in some experiments which will be presently detailed.

In order to test the method, copper No. 3 was fused in the pipe, and kept so for about half an hour, when we found the conducting power—

	Mean.
a. 92·57 at 17·8°	92·99 at 17·5°.
b. 93·40 at 17·2	

In this manner we have been able to reduce the suboxide in the copper by degrees: all the alloys made were fused in this manner, only substituting carbonic acid gas in cases in which hydrogen could not be employed.

We did not try to determine quantitatively the amount of suboxide present in the copper, as we know of no method which will give results which can be depended upon.* We shall only give the conducting power of copper that had been fused in contact with air. Thus copper, chemically purified, was fused with borax and chloride of sodium (the flux not quite covering the surface of the melted copper).

* Dick (Phil. Mag., June, 1858) could not obtain any good results by any of the known methods. All the experiments which we have made agree with his, especially concerning the action of ammonia on copper.

The conducting power of this specimen was

		Mean.
I.	*a.* 69·44 at 24°·2 *b.* 69·38 at 23·5 *c.* 69·30 at 24·0	69·37 at 23°·9.

This was then kept fused for several hours in a porcelain tube in a current of hydrogen; it then conducted—

		Mean.
II.	*a.* 87·20 at 18°·8 *b.* 85·50 at 19·0	86·35 at 18°·9.

This was next treated in the above described manner in the tobacco pipe, first for half an hour, and then for three hours, which caused the conducting powers to increase the following values:—

		Means.
III. After half an hour,	*a.* 89·32 at 17°·0 *b.* 91·07 at 17·8 *c.* 88·40 at 17·4	89·57 at 17°·4.
IV. After three hours,	*a.* 92·63 at 18·0 *b.* 93·36 at 19·2	93·00 at 18°·6.

Similar results were obtained with galvanoplastically precipitated copper, which had been fused in contact with air under a small quantity of borax and chloride of sodium.

		Means.
I. Fused in contact with air, . .	*a.* 73·20 at 19°·3 *b.* 73·08 at 19·4 *c.* 73·69 at 19·8	73·32 at 19°·5.
II. No. 1, fused in a tobacco-pipe for half an hour, as above described, . .	*a.* 76·27 at 17·6 *b.* 75·55 at 17·7 *c.* 75·38 at 17·8	75·73 at 17·7.
III. No. 1, fused one hour in pipe, . .	*a.* 83·14 at 16·8 *b.* 82·25 at 17·0	82·70 at 16·9.
IV. No. 1, fused for one hour and three-quarters in pipe, ...	*a.* 90·36 at 19·7 *b.* 91·00 at 19·7	90·68 at 19·7.
V. No. 1, fused for three hours in pipe, .	*a.* 91·92 at 18·5 *b.* 92·76 at 18·1	92·34 at 18·3

From the above experiments we see how difficult it is to reduce the whole of the suboxide; a fact which explains the reason why no good determinations as to the amount of oxygen present in copper have as yet been obtained.

2. *Effect of Carbon.*

According to Karsten,* copper takes up 0·2 per cent. of carbon; we could not, however, obtain wires containing more than 0·05 per cent. This small quantity causes the conducting power to decrease considerably. Thus, galvanoplastic copper in small pieces was fused down with lamp-black, and gave, upon analysis, 0·05 per cent. of carbon;† and for the conducting power we found

	Mean.
74·29 at 18°·1 75·53 at 18·5	74·91 at 18°·3.

* Schweigger's Journal fur Chemie u. Physik, lxvi., p. 395.

† We repeated this experiment several times, but could not again make the alloy. In all probability, therefore, the carbon found was only mechanically mixed with the copper.

3. *Effect of Phosphorus.*

Phosphorus alters the properties of copper to a very great extent; it becomes very much harder, and its tenacity is greatly impaired. Of all the impurities, this has the greatest reducing effect on the conducting power of copper.

Red phosphorus was thrown on melted copper in a tobacco-pipe and re-fused. The amount of phosphorus was determined as phosphate of magnesia.

		Means.
I. Copper with 2·5 per cent. of phosphorus,	*a.* 7·37 at 17·0 ° *b.* 7·11 at 18·0	72·24 at 17·5
II. Copper with 0·95 per cent. of phosphorus,	*a.* 23·43 at 22·3 *b.* 23·05 at 22·0	23·24 at 22·1.
III. Copper with 0·13 per cent. of phosphorus,	*a.* 67·88 at 20·0 *b.* 67·46 at 20·0	67·67 at 20·0.

4. *Effect of Sulphur, Selenium, and Tellurium.*

Sulphide of copper does not appear to dissolve in copper, but merely to mix with it mechanically. It makes the copper very brittle; and although we succeeded in drawing a wire which contained according to the analysis 0·18 per cent. of sulphur, the values obtained for the conducting power did not agree at all with each other. The mean of four determinations gave 88·58 at 19·4°.

Traces of sellenium and tellurium make copper so rotten that we were unable to draw it.

5. *Effect of Arsenic.*

When arsenic is thrown upon melted copper, the greater part of it is absorbed, whilst a part volatilizes; and on re-fusing the alloy formed, if a large quantity of arsenic has been used, it has a dingy grey color, and is very hard and brittle. We managed to draw an alloy containing 5·40 per cent. of arsenic to the diameter of 0·29 millim.; and had we had draw-plates with finer holes at our disposal, we might have drawn it much finer—a fact which does not at all agree with the assertions lately made, that copper with a small amount of arsenic cannot be drawn into fine wire. The arsenic was determined as arseniate of magnesia. The following values show that arsenic greatly reduces the conducting power of copper:—

		Means.
I. Copper with 5·40 per cent. of arsenic,	*a.* 6·17 at 16.7 ° *b.* 6·19 at 17·0	6·18 at 16 8.
II. Copper with 2·80 per cent. of arsenic,	*a.* 12·97 at 18·8 *b.* 13 38 at 19·4	13·14 at 19·1.
III. Copper with traces of arsenic,	*a.* 57·72 at 19·5 *b.* 57 89 at 19·9	57·80 at 19·7.

6. *Effect of Heating in a Current of Ammonia.*

Several experimenters state that, when copper is heated in ammonia, the gas is decomposed and nitride of copper formed, a fact which Schrotter* disputes, and has been proved totally incorrect by Dick.

* Gmelin, vol. iii., p. 416.

We repeated the experiment by heating a copper wire, whose conducting power had been previously determined, for a quarter of an hour in a current of dry ammonia: when cold, the conducting power was found the same, and the wire was as ductile as before. In all probability the reason why, in the experiments of previous observers, the copper became brittle, was (as already suggested by Dick) that they used copper containing suboxide.

7. *Effect of the Metals.*

The electric conductivity of copper is not so much impaired by the presence of small quantities of foreign metals as by that of the metalloids; it is, however, very considerably diminished by iron and tin.

The union of the copper with the other metals was effected in the manner before described, which offers in this case the additional advantage that, by the constant movement caused by the hydrogen in the melted metals, the most intimate combination results. The amount of the metals thus alloyed with the copper was determined by analysis.

	°	Means.
I. Copper* alloyed with 3·20 per cent. of zinc,†	*a*. 56·96 at 10·0 *b*. 57·01 at 10·6	56·98 at 10·3.
II. Copper with 1·60 per cent. of zinc,	*a*. 76·25 at 15·2 *b*. 76·45 at 16·4	76·35 at 15·8.
III. Copper with traces of zinc,	*a*. 85·67 at 18·0 *b*. 84·43 at 20·0	85·05 at 19·0.
IV. Copper with 1·06 per cent. of iron,	*a*. 27·44 at 14·2 *b*. 26·46 at 12·0	29·95 at 13·1.
V. Copper with 0·48 per cent. of iron,	*a*. 34·40 at 11·0 *b*. 34·72 at 11·4	34·56 at 11·2.
VI. Copper with 4·90 per cent. of tin,	*a*. 19·35 at 14·2 *b*. 19·60 at 14·6	19·47 at 14·4.
VII. Copper with 2·52 per cent. of tin,	*a*. 32·49 at 17·0 *b*. 32·79 at 17·2	32·64 at 17·1.
VIII. Copper with 1·33 per cent. of tin,	*a*. 48·76 at 16·8 *b*. 48·28 at 16·8	48·52 at 16·8.
IX. Copper with 2·45 per cent. of silver,	*a*. 80·01 at 19·6 *b*. 79·21 at 19·8 *c*. 78·93 at 19·8	79·38 at 19·7.
X. Copper with 1·22 per cent. of silver,	*a*. 87·61 at 20·6 *b*. 86·65 at 20·6 *c*. 86·46 at 21·0	86·91 at 20·7.
XI. Copper with 3·50 per cent. of gold,	*a*. 65·10 at 18·0 *b*. 65·80 at 18·2 *c*. 66·00 at 18·1	65·36 at 18·1.

We could not draw a wire of pure copper with only traces of lead in it, for it makes the copper to all appearance perfectly rotten; in Gmelin's 'Chemistry' it is also stated that copper which contains even 0·1 per cent. of lead cannot either be drawn into fine wire or rolled into thin sheets. Now the copper smelters add a small quantity of lead to their copper to soften and render it more tough. The addition of lead is supposed to reduce the suboxide of copper present; but,

* All wires hard drawn.

† All the metals employed were pure.

according to J. Napier's* analysis, lead was always found present where it had been added, and often in quantities equal to the amount which had been put in. We have therefore made a few experiments in this direction.

To copper fused in contact with air, 0·1 per cent. of lead or tin was added, and the alloy fused in the tobacco-pipe in a current of carbonic acid gas.

		Means.
I. The copper employed conducted . .	*a.* 83·44 at 13°·0 *b.* 84·45 at 13·6	83·94 at 13°·3.
II. With addition of 0·1 per cent. of tin, .	*a.* 90·00 at 14·0 *b.* 89·80 at 14·0	89·90 at 14·0.
III. The same repeated, . . .	*a.* 91·27 at 13·8 *b.* 90·65 at 14·0	90·96 at 13·9.
IV. With addition of 0·1 per cent. of lead, .	*a.* 89·55 at 12·0 *b.* 89·42 at 13·8	89·48 at 12·9.

The quantity of lead and tin remaining was so small that it was not possible to determine it quantitatively.

The experiments, however, tend to prove that on the addition of traces of lead, &c., to copper containing suboxide, a relatively purer metal is obtained.

From the foregoing experiments, we may conclude that *there is no alloy of copper which conducts electricity better than pure copper;* and, in conclusion, in order to be able to compare their results with those of others, we would call the attention of experimenters—

I. To the importance of stating whether the wires experimented with are hard drawn or annealed, as it makes in some cases a very marked difference in the values obtained.

II. To the influence of temperature on the conducting power. We find in very few cases the temperature stated at which the observations have been made.

* Philosophical Magazine, S. 4, v. p. 488.

Trans. Royal Society.

The Smelting Furnace.

An ancient furnace-master in France, M. Joseph Bonne, has proposed certain modifications in the construction of iron-furnaces, which are highly lauded by the Editor of the *Cosmos*, and may be worthy of the consideration of our iron-masters. We give the substance of the article from the *Cosmos*:—

"In the present iron-furnaces, whose dimensions are too great, and whose height frequently reaches 45 feet, it is almost impossible properly to control the charges. The quantity of ore introduced is scarcely ever what it ought to be in relation to the fuel. If the charge is too small, the fuel is burned uselessly; if the charge is too great, the metal is white and brittle. Often the furnace is '*en débauche*,' according to the energetic expression of the workmen, and it must be *thrown out;* that is, the furnace must be emptied and suffered

to cool, and the work resumed under better auspices. Now these throwings out, which are repeated several times in a year, are ruinous. Under less unfavorable circumstances, we must at least wait twenty-four hours to know whether the modifications of the charge have produced the desired effect, and the furnace has been brought back to its usual condition. There is a general and just complaint of the ignorance and want of skill of the guards and chargers; but it is fair to acknowledge that the bad construction and exaggerated dimensions of our furnaces are an invincible barrier to the proper education of the workmen, and to their acquisition of a correct experience. Impossible as it is for them to understand the results which follow the arbitrary changes which they have thought proper to try, they allow themselves to be ruled by the furnace, instead of ruling it, and reason on nothing.

"The furnace of M. Bonne will never be over 27 feet in height; its content will be twenty charges of a cubic metre (35 cubic feet) each. Associated together in the service, the guard and charger will arrange with each other for feeding the furnace. As ten charges will be run, they will collect the product of the mixture made by them, and will see at once by the quality of the metal and the behavior of the furnace whether any thing ought to be changed in their management. In this way they will be compelled to learn their business; they will study it, and learn to work carefully and economically. To stimulate their zeal, M. Bonne requires them to keep a separate account of the fuel expended, and pays them in proportion to the quantity of metal produced. As the ore and fuel are for a long time the same, as each associated guard and charger run out the product of their own charge, judge for themselves, and see how their work is to be corrected, it is impossible that they should not arrive at a perfectly regular production.

"The principal innovation by M. Bonne is in the construction of the crucible. Rejecting the thick masonry which has continually to be built up and pulled down, which loses so much time in drying and in starting; he forms his crucibles simply of four stout curved plates of cast iron, firmly tied together from the bottom to the upper edges, and coated on the inside with fire-brick and clay. The cast-iron apron covers the whole front of the furnace, and is pierced with two holes, one below for the running of the metal, the other above, for the slag, which runs off of its own accord into a car, and is wheeled out when the car is full. The *estallages* are vaulted of fire-brick; the throat is entirely closed except the openings left for the gas-pipes, which are led to the boilers, or to the perpetual lime-kilns. A movable cover balanced by counter-weights is placed on top of the charge, to retain the heat in the furnace, and drive the gas into the tubes.

"M. Bonne is certain that these modifications will result in, first, an economy of more than 30 per cent. of the fuel consumed; secondly, an economy of 20 per cent. in the wages, by the reduction in the number of the workmen; thirdly, an economy of 50 per cent. in the expense of building, heating, and re-heating.—*Cosmos.*

On a Bathometer, or Instrument to indicate the Depth of the Sea on board Ship without submerging a Line. By C. W. Siemens.

From the Lond. Civ. Eng. and Arch. Journal, Nov., 1861.

Those who are acquainted with the difficulties and expense attending the taking of deep-sea soundings by means of a weighted line, will readily perceive that an instrument capable of indicating depths upon a graduated scale in the cabin of the vessel would be of great advantage, as a means of extending our knowledge of ocean geography. In laying submarine telegraph cables through deep seas, such an instrument would be invaluable.

It occurred to the writer that the total attractive force of the earth must be sensibly influenced by the interposition of a comparatively light substance, such as sea-water, between the vessel and the solid portion of the earth below. This he demonstrated geometrically as follows:—Assuming the earth to be a perfect sphere of uniform density, two lines are drawn from a point on the surface, so as to intercept the circumference at the semicircles. A line is then drawn through the two points of intersection, which passes through the earth's centre, and a second line parallel to it, touching the circle at its lowest point. It was next demonstrated, that in dividing the solid cone represented by these lines into a number of slices of equal thickness, in a direction perpendicular to its axis, each slice would exercise the same amount of attractive force upon a body at the apex of the cone; the reason being that the mass of each slice increases in the proportion of the square of its distance from the apex, and the attractive force diminishes in the same ratio.

It was thus demonstrated that the true centre of gravity of the earth in reference to an attracted body on its surface does not reside in its geometrical centre, but in a variable point between the centre and the attracted body. In dividing the sphere itself into slices of equal thickness a mathematical expression was obtained, representing the attractive force of any of these slices; and in integrating this expression for a series of slices it was the following formula:—

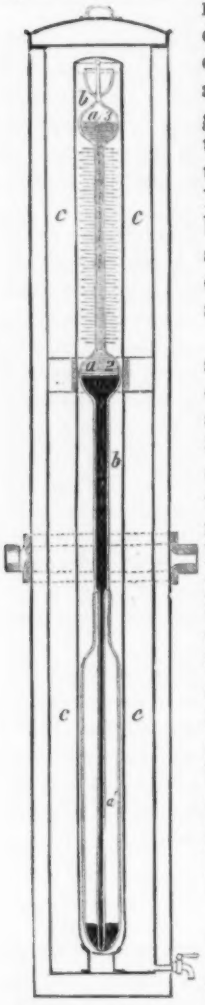
$$A_1 = 2\pi h \left(1 - \frac{2}{3}\sqrt{\frac{h}{2R}}\right)$$

in which A_1 signifies the attraction of the piece of the sphere sliced off, h the depth of this piece, and R the radius of the earth. In substituting $2R$ for h, the formula gives the total attraction of the earth, $A = \frac{4}{3} R\pi$, agreeing with Newton's formula.

Considering that the depth of the sea, which is represented by h, is exceedingly small as compared to $2R$, the expression $\sqrt{\frac{h}{2R}}$ may be entirely neglected, and the first formula may be written $A_1 = 2\pi h$.

Consequently, $A : A_1 = \frac{4}{3} R\pi : 2\pi h$, or, $A_1 : A = h : \frac{2}{3} R$.

For moderate depths the attraction of the earth may be represented by a very obtuse cone, with $\frac{2}{3}$ R for its height. If sea-water were of no weight, the total attraction of the earth would be diminished upon its surface in the proportion as the depth to $\frac{2}{3}$ R; but considering that sea-water has about one-third the weight (bulk for bulk) as the generality of rock, the actual diminution of gravitation was shown to take place in the proportion of the depth to the radius of the earth. Accordingly, 1000 fathoms of depth would produce a diminution by $\frac{1}{3200}$ part of the total gravitation, a difference so small, that it appears at first sight impossible to construct an instrument capable of indicating it with sufficient accuracy.



The second part of the paper described the instrument designed for this purpose, which consists of a tube containing mercury, diluted spirits of wine, and colored juniper oil. The mercury column, about 30 inches high, ascends in a tube from the bottom of a large bulb a^1, containing imprisoned air, and terminates in the middle of a second bulb a^2. The remainder of the second bulb is filled with the diluted spirits, which reach upward into a narrow tube provided with a scale. Upon this rests a column of the colored oil, which terminates in a third bulb a^3, the remaining space being vacuous, or nearly so. This gauge is inclosed in a glass tube *b b*, filled with distilled water, which in its turn is surrounded with ice, *c c*, contained in an outer casing: the latter is suspended by a universal joint. The air in the lower bulb, being maintained in this way at a perfectly uniform temperature, will oppose a uniform elastic force against the column of mercury, which latter, being removed from all atmospheric influences, fairly represents the gravitation of the earth.

In moving this instrument from shallow water upon a sea of 1000 fathoms depth, the mercury column would rise $\frac{1}{3200}$ part of its length in the second bulb; but before any sensible attraction has taken place in the mercury level, the upper surface of the spirits of wine terminating in the narrow tube will have risen sufficiently to restore the balance of pressure, and the spirits being 20 times lighter than mercury, the scale of observation would be increased twentyfold. But the spirit column, in rising, displaces oil of very nearly the same specific gravity, which causes another increase of scale at least twentyfold. By these means a scale of 3 inches per 1000 fathoms of depth is obtained.

An instrument of this description was tried by permission of the Admiralty, and although it was still imperfect in some respects, its

indications agreed generally within 10 per cent. with the results of actual soundings.

In the course of the discussion which ensued, Prof. Tyndall suggested that the instrument would be equally applicable for measuring heights.

Destruction of Insects in Grain. By M. Louvel.

In M. Louvel's plan, the grain is put into a hollow cast iron cylinder, from which the air is then exhausted. No animal can then live in it: fermentation itself stops, since it has neither air nor moisture, without which it cannot continue. On a large scale, M. Louvel makes his vacuum, by previously filling another cylinder provided with proper valves, with steam of four atmospheres pressure, and then condensing the steam. A communication is then opened between this generator, as it is called, and the cylinder containing the grain. A vacuum of 38 centim. (15 inches) is easily obtained and perfectly effective. Indeed, M. Louvel has found that 50 centim. (19·7 inches) was quite sufficient for the purpose.—*Cosmos.*

Cement for Rooms.

From the London Builder, No. 992.

A recent invention by M. Sorel is described to us. He states that the invention consists in the discovery of a property possessed by oxychloride of zinc, which renders it superior to the plaster of paris for coating the walls of rooms. It is applied in the following manner:—"A coat of oxide of zinc mixed with size, made up like a wash, is first laid on the wall, ceiling, or wainscot, and over that a coating of chloride of zinc applied, being prepared in the same way as the first wash. The oxide and chloride effect an immediate combination, and form a kind of cement, smooth and polished as glass, and possessing the advantages of oil paint, without its disadvantages of smell," &c.

For the Journal of the Franklin Institute.

Remarks on Mr. C. J. W., Jr.'s "Analysis of the Gamut in the Major and Minor Modes. By J. C. B.

To the Editor of the Journ. of the Frankl. Insti.

A friend having handed me a copy of your March No. containing an article "Analysis of the Gamut of the Major and Minor Modes," I desire to express my gratification on finding at least *one* scientific gentleman, so much interested in the "Art Divine" as to write a lengthy article on the subject. Although the conclusions of the writer are in the main just, yet the roundabout way in which he reaches them, is not, in my opinion, calculated to make them practical, which, after all, is the great desideratum in theory. I allow him, however, great credit for his originality. The immediate object of this communication is, to refer your readers to a work, viz: "The Introduction to the *Art* and *Science* of Music," by Phil. Trajetta, which is considered good authori-

ty on this subject. In its Preface we read, "There are systems of music like that of Tartini, so *entangled* with *mathematics*, that unless the reader is a *mathematician*, he cannot understand them." Also Less. xx. (2) "There are three principal sounds of the Diatonic Genus which are at the foundation of Harmony. These sounds are the *Tonic*, the fourth and the fifth or *Dominant*," and Less. xxii. (3) "When an alteration or diminution is given to the sounds of the Diatonic Genus, the key changes, viz: The musical phrase proceeds to another key. A sensible alteration would be that of the fourth, if made major (F to F sharp). A sensible diminution that of the seventh, when made minor, (B to B flat.)" These two propositions include all the theory of your correspondent. Hoping he may give us a more practical application of the subject, I remain, &c.

PHILADELPHIA, April 15, 1862.

Russian Method for the Preservation of Fruits, Vegetables, &c.

At the last Exhibition at St. Petersburgh, the following mode of preserving fruits, invented by the *maitre d'hotel* of the Grand Duke Nicholas, attracted great attention from amateurs. Quick-lime is slacked in water, into which four or five drops of creosote for each quart of water have been mixed: the lime must be neither too much nor too little slacked; there is a certain knack which practice alone can teach. Take a box and lay in its bottom a bed of the slacked lime, above this spread a layer of the materials to be preserved; at the four angles and elsewhere lay packages of powdered charcoal; then make another bed of the lime, followed by another layer of the fruit. When the box is full put on the lid, and close it air-tight. Thus preserved, the fruits will last a whole year.—*Cosmos.*

Proper Time of Year for Cutting Wood.

Four pine trees of the same age, equally sound, which had grown on the same soil and under the same conditions, were chosen. The first was cut at the end of December; the second, at the end of January; the third, at the end of February; and the fourth, at the end of March. They were shaped in the same manner, into beams of the same dimensions, and seasoned under the same conditions. Their resistances to bending were then determined by laying them on supports and loading them at the middle. The resistance of the first beam (that felled in December) being called 100; that of the second was 88; of the third, 80; and of the fourth, 62.

Similar results were obtained as to the durability and strength of posts made of sticks cut at the end of December and of March. The first were still perfectly sound after 16 years; the second at the end of 3 or 4 years broke with the slightest effort. All were buried in the same soil and under the same conditions.

Four oaks as like as possible, and placed in the same conditions, were cut at the end of December, January, February, and March. A disk of the same thickness was cut from each at the same height above

the ground, and was made the bottom of a vessel filled with water; the sizes of the vessel and height of the water being the same in all. The first (cut in December) allowed no water to pass; the others passed more or less; that cut in January, at the end of 48 hours; that of February, before the end of the second day; that of March, in two hours.

Two similar oaks were selected and felled, the one at the end of December, the other at the end of January, and staves made of the wood. Barrels were made of them, which were soaked in the same way, and then filled at the same time and with the same wine. In a year the barrel made of the wood cut in December had lost 0·14 quart, while the other had lost 7·2 quarts.—*Cosmos.*

Arsenical Pigments in Common Life. By Dr. A. W. Hofmann, F.R.S., Professor at the Royal College of Chemistry.

From the London Chemical News, No. 114.

The following letter has been addressed by Professor Hofmann to the Right Hon. W. Cowper:—

In accordance with your wishes, I have examined carefully the green coloring matter of the artificial leaves from a lady's head-dress which you have sent me.

It is well known that such leaves generally contain arsenic, and often in considerable quantities. An experienced eye readily recognises the presence of an arsenic color (Schweinfurt green) by its brilliancy, the intensity of which is as yet unrivalled by any other green. However, should there remain the slightest doubt, an experiment of the simplest kind would establish the fact. In most cases it would be sufficient to burn such a leaf in order at once to perceive the garlic odor which characterizes the presence of arsenic.

In a dozen of the leaves sent to me analysis has pointed out on an average the presence of ten grains of white arsenic. I learn from some lady friends that a ball-wreath usually contains about fifty of these leaves. Thus, a lady wears in her hair more than forty grains of white arsenic,—a quantity which, if taken in appropriate doses, would be sufficient to poison twenty persons. This is no exaggeration, for the leaves which you have sent me were, some of them at least, only partly colored, others only variegated. In consequence of your inquiries, I have been led lately to pay more than usual attention to the head-dresses of ladies, and I observe that the green leaves are often much larger and more deeply colored than those which I received.

The question how far arsenic-dyed wreaths may be prejudicial to health is intimately connected with the discussion, so frequently raised of late years, as to the influence which arsenic-colored paper-hangings exert upon the human system. This influence has been doubted on various grounds, both by the chemist and the physician. The alleged effect has been attributed to the development of arseniuretted

hydrogen, or some other volatile arsenic compound, to which the white arsenic, by the action of the damp on the wall, or of the organic constituents of the paper and the paste, might possibly have given rise. Accurate experiments, however often repeated and often varied, have proved the inadmissibility of the assumption of gaseous arsenic exhalations, and, as it so often happens, the injury was denied simply because it could not be explained. Nevertheless, the deleterious effect of arsenic green paper-hangings is at present pretty generally acknowledged. Indeed, it does not require any high-flown hypothesis to explain the transfer of the arsenic from the wall to the system. The arsenic dust, bodily separated from the wall and dispersed over the room, is quite sufficient for this purpose. The investigations of the last few years have clearly shown the presence of arsenic in the dust of rooms hung with arsenic-green paper, even when this dust had been collected at the greatest possible distance from the walls. Moreover, the chronic poisoning by arsenic of persons living in such rooms has been proved experimentally, inasmuch as the presence of arsenic may be demonstrated in their secretions, more especially if the elimination of the poison be accelerated by the administration of iodide of potassium.

The employment of arsenic green in the manufacture of paper-hangings ,in staining paper, in painting children's toys, &c., has attracted the attention of the sanitary authorities on the Continent for many years past. In several of the German States, more particularly in Bavaria, the very country of arsenic colors (which are manufactured on a very large scale in Schweinfurt, a town in Franconia), the application of these colors to papering or painting rooms has been repeatedly proceeded against. I have before me an edict of the Bavarian Government of July 21, 1845, expressly prohibiting the manufacture and sale of arsenic-green paper-hangings. This general prohibition, it is true, was repealed by an Act of January 23, 1848, "for industrial considerations," and the use of Schweinfurt green permitted as before for house papering and painting, provided the colors were permanently fixed by appropriate means. The relaxation of the measures against Schweinfurt green appears, however, to have given but little satisfaction. In several papers laid both by chemists and physicians before the Academy of Munich, in its sitting of June 9, 1860, undoubted cases of chronic poisoning produced by arsenic papers, even when glazed, were brought forward, and the Academy was called upon to represent to the Government the necessity of strictly enforcing the former regulations against arsenic colors, and of removing all Schweinfurt-green wall-coloring from public buildings, schools, hospitals, &c.

The immense consumption of arsenic colors, and their reckless use under various conditions prejudicial to health, certainly claim the especial notice and the consideration of the public. Not satisfied with poisoning the wreaths which adorn the heads of our women, modern trade introduces arsenic without scruple even into their dresses. The green tarlatanes so much of late in vogue for ball dresses, according to an analysis made by Professor Erdmann, of Leipsic, contain as

much as half their weight of Schweinfurt green. The color is loosely laid on with starch, and comes off by the slightest friction in clouds of dust. I am told that a ball dress requires about twenty yards of material—an estimate probably below the mark, considering the present fashion. According to the above analysis, these twenty yards would contain about 900 grains of white arsenic. A Berlin physician has satisfied himself that from a dress of this kind, no less than 60 grains powdered off in the course of a single evening.

It will, I think, be admitted, that the arsenic-crowned queen of the ball, whirling along in an arsenic cloud, presents, under no circumstances, a very attractive object of contemplation; but the spectacle, does it not become truly melancholy when our thoughts turn to the poor poisoned artiste who wove the gay wreath, in the endeavor to prolong a sickly and miserable existence already undermined by this destructive occupation!

Ladies cannot, I think, have the remotest idea of the presence of arsenic in their ornaments. If aware of their true nature, they would be satisfied with less brilliant colors, and reject, I have no doubt, these showy green articles, which have not even the merit of being, as far as coloring is concerned, a truthful imitation of Nature. There being no longer a demand for them, the manufacture of poisonous wreaths and poisonous dresses would rapidly cease as a matter of course.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, April 17, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from Col. S. H. Long, Bureau U. S. Topographical Engineers, Washington, D. C.

Donations to the Library were received from the Royal Society, the Royal Geographical Society, London, and the Literary and Philosophical Society, Liverpool, England; the Bureau of Topographical Engineers, Washington City, D. C.; Prof. Daniel Treadwell, Cambridge, Mass.; William Bryson, Esq., and J. Spencer Turner, Esq., Chicago, Ill.; the Board of Water Commissioners, Detroit, Mich.; the Young Men's Mercantile Library Association, Cincinnati, Ohio; and George M. Conarroe, Esq., and Prof. Frazer, Philadelphia.

Donations to the Cabinet of Models—from L. C. Francis, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of March was read.

The Board of Managers and Standing Committees reported their minutes.

Three resignations of membership in the Institute were received and accepted.

Candidates for membership in the Institute (9) were proposed, and the candidates proposed at the last meeting (2) were duly elected.

Mr. T. Fisler exhibited a Feed-Bag for horses. It consists of a feed-bag of the ordinary form, to the bottom of which can be attached at pleasure a jointed rod, which may be folded up with the bag so as to readily pack to the saddle when not in use. A strap passes over the head of the horse so as to hold the bag in position, the end of the jointed rod resting upon the ground and supporting the bag, so that the animal can obtain all the feed that is in it without tossing it up, as is necessary with the form of feed-bag usually employed. This is particularly useful for cavalry, or those who carry their horse-feed with them, in traveling.

Mr. Edward Longstreth exhibited and explained a patent Oil-Can for oiling valves and pistons while under pressure, without cutting off the steam; also, some specimens of malleable Horse-shoe Nails, made by machinery invented by Mr. William C. Grimes, of Philadelphia.

Mr. Charles S. Close exhibited a Stove for army purposes, having the plates united by scroll joints, which may be folded up when not in use, so as to occupy but a small space.

Mr. L. O. Colvin exhibited the Lamp and Apparatus of an Optical Telegraph, patented by himself and G. H. Gordon, March 11, 1862, and remarked, that a light made to appear and disappear, corresponding to the dots and dashes of Prof. Morse's telegraphic alphabet, can readily be used as a means of communication as far as the light can be seen, the distance depending upon the strength of the light used. But in order to make telegraphing in this manner *successful*, certain things are essential. A strong, regular light must be produced, and so arranged that the light be made to appear and disappear suddenly and with ease in signaling the letters.

The invention combines a lantern and reflector, provided with a shutter operated by hand or by electro-magnetism. The lantern is built to produce the best possible light from the substance consumed, protecting the flame from outside currents of air, retaining the heat by the use of plaster of paris, and also supplying the burner with a constant and copious quantity of air; the whole tending to secure the most perfect combustion. The brilliant light thus produced is used to the greatest possible advantage; the best rays of light proceeding from any flame are the direct rays and those adjacent; these are secured. A reflector made in the shape of a horn or funnel is placed wholly in front, with the small end to the light; the direct rays pass through unobstructed, while the reflected light is reflected so near its source and bent so little from its direction as not to diminish its intensity. The real light appears in the centre, encircled with a perfect halo of reflected rays, throwing in front a light the full size of the large end

of the reflector, appearing at a distance like a perfect ball of fire. Having the cut-off, as you see, at the small end of the reflector, it becomes very easy to expose the light to view in making the signals with facility—since the shutter is so small and light, and the distance it is necessary to move it is so short, being only to uncover the size of the flame—thus gaining the advantage of a large light, though working a small cut-off, which could not be done by any other style of reflector. By this construction the letters can be signaled perfectly,

o *p* *t* *i* *c* *a* *l*,

(- -) (- - - - -) (—) (- -) (- - -) (- —) (——)

and read with all ease by any telegraph operator. The shutter can be easily worked by hand, or better by electricity. An electro-magnet placed so that its armature, attached to the lever of the cut-off, by being attracted to the magnet, opens the shutter; by making and breaking the current with the battery, the light is exposed to view as desired. Thus making it still more easy to operate, telegraphing by light becomes the same in operation as by the common telegraph. The lantern thus constructed can be placed at any convenient position—the mast-head of a ship, top of a tree, or tower of a lighthouse—and worked from below at the pleasure of the attendant. Another operator at a distance reads the letters as they are signaled, and copies down the message.

There is no difficulty in telegraphing secret messages. If you remove the vowels from a page of reading, what can you make of it? Nothing. Our plan is to arrange the letters *a e i o u w y* in a table, with figures to represent them; the arrangement can be used 49 different ways, and can be changed at any time. Used in this manner, write off the dispatch, make the substitutions, and give it to the operator; it is sent and received as given, and taken to the person for whom it is intended; he having a key, makes the substitutions back again, and reads the message—the operators knowing nothing of the import of the message they have telegraphed. *Optical* by one substitution might appear thus: 4pt2c5l.

Light in many respects is as well adapted for telegraphic purposes as electricity; it is as fleet in its journey, and with an apparatus constructed to suit its nature, it will do its work as rapidly and distinctly. By this plan a system of communication can be established along our whole coast *via* the ships of war and the lighthouses, by which messages may be sent and received from any portion of our blockading fleet every night, with just as much certainty and despatch as if a cable connected the different points and the electric flash conveyed the intelligence.

Mr. E. L. Snow exhibited Haley, Morse, & Boyden's machine for squeezing the water from washed clothing, termed by them, "Self-adjusting Clothes Wringer." It consists of a wooden frame carrying two rollers of vulcanized india rubber, rolling together and kept in close contact by levers and gum springs. The frame is arranged so as to be clamped to the wash-tub, and motion is given to the rollers by a

crank handle. A piece of washed clothing can have one end or a corner inserted between the rollers, which, when turned, draws the piece through from the tub and delivers it into a basket placed to receive it, whilst the extracted water falls upon a piece of wood fixed beneath the rollers, and inclined towards the wash-tub, in order to convey the water back. It is claimed to be a quicker and less injurious process than that of wringing, and that buttons or hooks and eyes pass through without injury to themselves or to the rollers.

It is also claimed that the twisting or wringing of clothes stretches and breaks the fibres; but this machine presses them so evenly that a newspaper thoroughly soaked can be squeezed without breaking it in the least, and it works so easily that a child twelve years old can operate it without trouble. Hot water does not injure the rolls, and woolen goods can be squeezed out of boiling water when used to prevent fulling, which cannot be done by hand.

In starching, it is valuable, especially on large articles, such as ladies skirts, &c., as it leaves the starch in the clothes perfectly even. It will squeeze the largest bed quilt or the smallest pocket handkerchief, dryer than can possibly be done by hand, without alteration, in less than one-eighth the time. The machine is so simple that it cannot get out of repair.

The great improvement in this water extracting machine is its self-adjusting arrangement, requiring no alteration to wring a hankerchief or bed quilt, consequently the most ignorant servant can operate it.

The machine being made of wood, is so arranged that no iron can possibly come in contact with the clothes, thereby avoiding all danger of injury to the clothes by oxide of iron.

Mr. A. L. Fleury exhibited apparatus and made the following remarks:—

Since Professor Faraday introduced the electric light in the light-house at South Foreland, near Dover, sending its intense rays through the dense fog, across the Channel, over a distance of twenty-seven miles, distinctly visible from the tops of the lighthouses on the French coast, the use of the electric light is becoming more and more extended over Europe; and, judging from certain indications, we may safely infer that the electric light will soon become successfully introduced into this country.

Nothing, in the way of light, has yet been produced that can compare with the beauty and brilliancy of the electric light; it converts, as we may fairly say, midnight into noonday.

Applied on steamers and vessels, immense advantages for the safety of the public, and for insurance companies, will be derived, preventing the very frequent collisions at sea. Along dangerous coasts, during the winter months, how many ships are lost, how many lives are sacrificed, how many valuable cargoes are destroyed, from the want of a light sufficiently powerful to burst through the thick midnight haze of the storm, and warn the voyager of the hidden dangers ere it be too late! For coal oil factories, where lately even the best

safety lamp has been found to fail, as the exceedingly fine benzole vapors may take fire through the finest wire gauze, the electric light, entirely excluded from the atmosphere, will be safe, and, therefore, preferred to all other lamps. The same in mines, where, by a series of reflectors, the light can be thrown from shaft to shaft, or, by properly adjusted guide-wires, be slid down into the deepest mine. The interior of gunboats, rams, and diving-bells can thereby cheaply and safely be illuminated, proof against air and water. The storm may rage, the spray may dash over the ship, it cannot extinguish the electric light; placed under water, it will still burn, and throw its magnificent rays around it. There is no danger of explosion—no escape of nauseous gas.

Having shortly discussed the safety and adaptability of the electric light, we will now proceed to the most important point—the one of comparative cost. Prof. Faraday, to whom we are indebted for the first practical introduction of the electric light, gave preference to the magneto-electric machine over the use of the galvanic batteries, as being the least troublesome and most economical source of electricity. The following comparison will enable us to judge:—*To produce an electric light equivalent to* 800 *wax lights, it will require* 50 *couples of Bunsen batteries, of a large size, the expense of which for consumption of zinc, mercury, and acids, would be about three dollars per hour; while with the magneto-electric machine the same production of light will not cost more than* SIX CENTS *per hour; and even this cost can be still reduced, if, in place of steam, a water course or windmill is employed.* On steamboats, or in factories, mines, &c., the cost of the motive power for producing the electric light would be near to nothing, as there is always sufficient power to spare for this purpose.

When a rotary movement is given to the magneto-electric machine by any power whatever, *it instantly produces a current of electricity of a perfect regularity and continuity*, and this current can be regulated with the greatest facility to the degree of quantity and intensity required.

The machine has, moreover, the advantage of being always ready to work; this gives it a new superiority over the battery. Above all, when a certain number of elements are employed for putting the battery in movement, it entails so great a loss of time, that the agents of transformation are used for the first couples in action, before the last are ready to work.

Such is, under the threefold advantage of *power of production*, *lowness of price*, and *economy in time*, the greatness of the progress accomplished by the magneto-electric machine. The model of Baker's patent machines, now exhibited before the Institute, constructed by Messrs. Collier & Co., at Binghampton, N. Y., seems to me in every respect the best adapted for all purposes for which a larger quantity of dynamic as well as static electricity is required. A full description of this machine, with a fine engraving, will be given in a future number of the *Journal of the Franklin Institute.*

Comparing the several devices of electric lamps, models, and dia-

grams, which are here exhibited to the members of the Institute, we find those of Prof. Way, known as the Mercury Light, described in the *Journal of the Franklin Institute* for April, 1862, and those patented by Messrs. Henry M. Collier and Henry N. Baker, to be the best adapted and most economical of all. The former having been described before, I will now explain the construction and merits of the latter.

The invention consists, first, in certain means of controlling the positions of the electrodes, by which they are kept properly in contact with each other, as they wear away by the disengagement of the particles, without the difficulty experienced in keeping up a proper degree of separation between them. To produce a light in this way has generally been supposed to be impracticable; but the inventors, by long-continued experiment, have found that by employing an electric current of very low intensity, but large quantity, they are enabled to use the points in contact. The difficulty of keeping the carbon electrodes pointed has resulted from particles of carbon being carried over by the current of electricity from the positive to the negative pole of the electrodes. With a view to obviate this (viz: the depositing of particles from the positive unto the negative pole), the invention also consists, secondly, in frequently reversing the direction of the current. To obtain this change of direction, the current of electricity evolved from a magneto-electric machine is used without the intervention of a frotteur or brake-plate, or else the current from a galvanic battery can be used—there being arranged in the circuit a brake-plate or pole-changer, which is rotated by electricity, by clockwork, or by any suitable mechanical means to produce a frequent change in the direction of the current. This invention, dispensing with expensive machinery, is a valuable contribution to applied science, and will do much towards rendering this most brilliant light available.

In the production of electric light, preference has generally been given by scientific men to the employment of carbon electrodes, and these mostly in the shape of pointed pencils, as giving the most brilliant and desirable light; but so much difficulty has been heretofore experienced in securing the proper relative positions of the pencils, and in keeping them pointed, that electricians have been forced to very ingenious but expensive and often complicated mechanical appliances, to obviate these, the only apparent objections to the use of the desired carbon electrodes.

Any one who has examined the complicated mechanism of former electric lamps, must be struck with the remarkable simplicity and perfection of the apparatus originated and constructed by the Messrs. Collier and Baker, which secures most accurately the adjustment of the carbon points. Dispensing with all gearing, springs, screws, electro-magnetic regulators, or other complications, its simplicity is only equaled by an ordinary candlestick, and its appearance is about as unassuming.

The main feature of this lamp is a hole in a metallic strap or bridge,

which secures the position of the points, and regulates the feed or supply as fast as consumed. The carbon pencils being in vertical positions, the upper one is fed down by gravity, and the lower one as a float is fed up by its own buoyancy. The hole or orifice in the upper metallic strap or bridge, is of a diameter a *little less* than the body of the pencil, so as to permit a portion only of the point to pass through, and as fast as it is reduced in size by the oxidation and disengagement of particles during the process of combustion. The pencil is thus gradually and surely fed downwards, and the feed regulated and controlled by its own combustion.

Using an electric current of *large volume* and *low intensity*, as the Messrs. C. and B. much prefer, the electrodes may remain *in contact;* then the hole in the lower strap, being the same size as the body of the lower pencil, acts as a perfect guide to the pencil as it passes up through it, and the lower pencil resting its point against the point of the upper pencil, is thereby controlled in its feed upwards.

Using a current of *high* intensity, it being desirable to *separate* the *points* and maintain that distance, the feed of the lower pencil is regulated and controlled by reducing the size of the hole in the strap to correspond with the upper one, and for the same purpose.

Using a current of electricity constant in one direction, there is a tendency to an accumulation of particles of carbon on the negative electrode, and a consequent blunting of that point. To avoid this, the Messrs. C. and B. use a *to and fro current.*

In this invention the extremes of simplicity and cheapness are combined; the cost of the original lamp, and the one used by the Messrs. Collier and Baker in their experiments, was the paltry sum of $2·50. What can be cheaper, more simple, and yet efficient?

Having been long in pursuit of the cheapest and best electric lamp, for the production of a uniform, reliable, and brilliant light, I shall venture to write upon this one "Eureka."

We will add here another important application of the electric light, and speak of

Photo-Telegraphy.—Man, after having succeeded in securing the services of electricity as his messenger of thought, impressed another agent, swifter still than electricity—Light! Signals with lights have been known from time immemorial, but a regular system of telegraphing with flashes of electric light, is comparatively new, and of great value in field operations. The apparatus here exhibited to the members of the Institute, is the invention of Mr. William C. Bridges, of this city. It consists of a tube, containing a lens and one or more adjustable mirrors, in combination with such devices as will obscure or expose the lens, which is illuminated by the electric lamp or rays of the sun, reflected from the mirrors, or for moving differently colored plates of glass to the front of and away from the lens, so that on observing the latter from a distance, its exposure and obscuration, or the different colors seen, will be the means of informing the observer of the nature of the messages transmitted by the operator. It can easily be observed that any kind of signals may be transmitted at a distance of twenty

miles at a medium, and of fifty to sixty miles at a higher elevation; for instance, from one high mountain-top to another; but for these distances it is necessary to use a telescope attached to the frame of the apparatus. To interpret Morse's telegraphic alphabet, the signals must be guided by the length of time during which the lens remains obscured, and by the rapidity of the movements given to the disks, precisely as if guided by the ticks of a telegraph instrument. In some cases, for instance, in time of war, a secret system of signals, predetermined by the operators, may be used. Thus, flashes of light may be made the messengers of thought in such localities where the transportation of telegraphic wires and instruments are too expensive and impracticable. Every vessel should be provided with a *light* telegraph and a small steam-whistle, as by these means she would be enabled to correspond and signal at night, and at such distance where no other signs of intelligence can be discerned.

There is little doubt but that the application of magneto-electric machines for the production of light, and for all purposes where a large amount of electricity is required, will soon supersede the use of galvanic batteries. A few words relative to the importance of this machine for the *ordinary telegraph* may here not be amiss:—

The extent of telegraphs in the United States is increasing every day; the capital involved is upwards of ***six millions of dollars.*** To work the telegraph lines, it takes annually 720 tons zinc, worth $60,000; more than 1,000,000 pounds nitric acid, worth $120,000; and $30,000 worth of mercury; besides a considerable amount of sulphuric acid, &c.; *none of which are used by the magneto-electric machines for generating electricity* (a uniform and steady current being produced by Mr. Baker's last improved arrangement), *thereby giving them immense advantages over the galvanic batteries, both in economy and time.*

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

MARCH.—The mean temperature of March, 1862, was about 3½ degrees below that of the same month of 1861, and 2° below the average temperature of the month for eleven years.

The warmest day of the month was the 12th, of which the mean temperature was 48·3°. The thermometer reached its maximum (56°) on the same day.

The coldest day was the 1st, with a mean temperature of 32·3°. The minimum (22°) was reached on the same day.

The range of temperature for the month was 34°.

The temperature was below the freezing point on 14 days of the month, but it rose above that point in the course of the afternoon of every day.

The greatest change of temperature in the course of one day was 22°, on the 30th day of the month; the least was 6°, on two days, the 14th and 15th. The average daily oscillation of temperature for the month (14·44°) is still below the average.

The greatest mean daily range of temperature was 8·7°, between the 12th and 13th of the month; the least was 1·2°, and occurred four times, between the 1st and 2d, between the 14th and 15th, the 21st and 22d, and the 22d and 23d. The average daily range for the month was only 3·95°, which is 4½° less than for March of last year, and more than 2° below the average for eleven years. It was the smallest mean daily range observed in any March during the eleven years of observation. The nearest approach to it was 5·3°, in March, 1856.

The pressure of the atmosphere was greatest (30·173 inches) on the 9th of the month; and the greatest mean pressure (30·156 inches) occurred on the same day. The pressure was least (29·276 ins.) on the 3d. The least mean pressure for a day (29·390 ins.) occurred on the 16th. The average pressure for the month (29·782 ins.) was eleven-hundredths of an inch below that for March, 1861, and four-hundredths below the general average for eleven years.

The greatest mean daily range of atmospheric pressure was 0·447 of an inch, and occurred between the 14th and 15th days of the month; the least was 0·032 of an inch, between the 29th and 30th. The average mean daily range for the month (0·173 in.) was two-hundredths of an inch less than the average for the month of March for eleven years.

The force of vapor was considerably less than usual. It was greatest (0·389 in.) on the 10th, and least (0·081 in.) on the 26th of the month. The average for the month (0·159) was two-hundredths of an inch less than the general average.

The dew-point was highest (47·9°) on the 10th, and lowest (16·6°) on the 27th.

The relative humidity was greatest (95 per cent.,) on the 3d and 15th days of the month, and least (25 per cent.) on the 27th. The average humidity for the month was 6 per cent. greater than for March, 1861, and a little over 2 per cent. greater than the average for eleven years.

Rain or snow fell on eleven days of the month, to the aggregate depth of 3·509 inches, which is a little less than the amount which fell in March, 1861, but nearly two inches more than the average for eleven years.

There were but two days of the month, the 1st and the 7th, entirely clear or free from clouds at the hours of observation, and the sky was completely covered with clouds at those hours on nine days. The average amount of the sky covered with clouds during the month of March, 1862, was about 65 per cent.; during March, 1861, it was 57 per cent., and the average amount for eleven years is but 54 per cent. of the hemisphere.

On the evening of the 12th of the month, a lunar rainbow was visi-